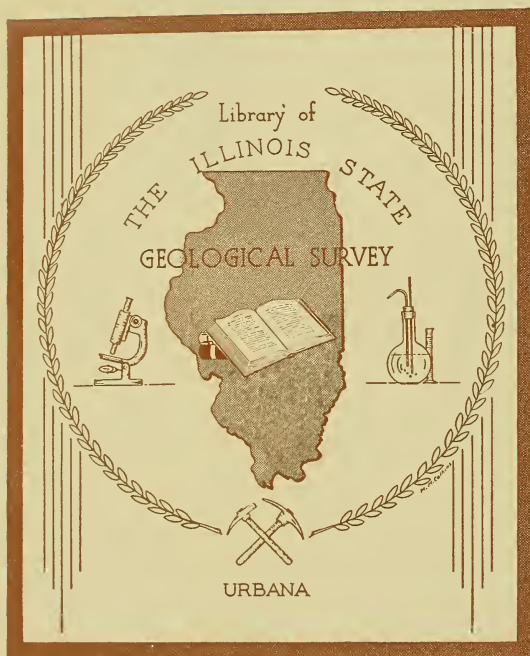


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STATE OF ILLINOIS
STATE GEOLOGICAL SURVEY
FRANK W. DEWOLF, Director

BULLETIN No. 35

OIL INVESTIGATIONS IN ILLINOIS IN 1916

UNDER DIRECTION OF FRED H. KAY

Petroleum in Illinois in 1916

By Fred H. Kay

Parts of Saline, Williamson, Pope and Johnson counties

By Albert D. Brokaw

Parts of Williamson, Union and Jackson counties

By Stuart St. Clair

The Ava area

By Stuart St. Clair

The Centralia area

By Stuart St. Clair

Parts of Hardin, Pope, and Saline counties

By Charles Butts

WORK IN COOPERATION WITH U. S. GEOLOGICAL SURVEY



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LETTER OF TRANSMITTAL

STATE GEOLOGICAL SURVEY
UNIVERSITY OF ILLINOIS, JANUARY 26, 1917

Governor Frank O. Lowden, Chairman, and Members of the Geological Commission.

Gentlemen: I submit herewith manuscript of reports on oil investigations in Illinois in 1916, and recommend their publication as Bulletin 35.

Because of its importance, part of this bulletin appeared in abbreviated form as an Extract, and development in the field described is now proceeding according to recommendations. The demand for these publications increases constantly.

Very respectfully,

FRANK W. DEWOLF, *Director*

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PETROLEUM IN ILLINOIS IN 1916

By Fred H. Kay

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GENERAL REVIEW

In spite of the fact that nearly twice as many wells were drilled in 1916, as the previous year, J. D. Northrup¹ estimates that the Illinois production for 1916 was 16,500,000 barrels, as compared with 19,041,695 barrels for the year 1915. This represents a decline of about 13.3 per cent as compared with a 13 per cent reduction for the year 1915. Table 1 shows the annual production and value of Illinois oil from 1905 to 1916, inclusive. According to present estimates, Illinois remains fourth in production for 1916, owing to the decline in the yield of the Louisiana fields.

The year 1916 was characterized by high prices which resulted in a large amount of development work and wildcat drilling. The decline in prices, beginning August first, curbed activity slightly during the fall months, but the prices at the end of the year and the general outlook are very encouraging to oil operators, and, unless some unforeseen event occurs, ac-

¹Northrup, J. D., U. S. Geological Survey Press Bulletin, January 8, 1917.

tivity will continue unabated. Table 2 shows the fluctuation in price per barrel for the two grades of Illinois oil for the year 1916. In 1916 there were 1,469 wells completed, according to the *Oil City Derrick* and the *Oil*

TABLE 1.—*Illinois oil production, 1905-1916*

Year	Barrels	Value
Previous	6,576	\$
1905.....	181,084	116,561
1906.....	4,379,050	3,274,818
1907.....	24,281,973	16,432,947
1908.....	33,686,238	22,649,561
1909.....	30,898,339	19,788,864
1910.....	33,143,262	19,669,383
1911.....	31,317,038	19,734,339
1912.....	28,601,308	24,332,605
1913.....	23,893,899	30,971,910
1914.....	21,919,749	25,426,179
1915.....	19,041,695	18,655,850
1916.... (estimate)	16,500,000	27,060,000

and Gas Journal. Of these 1,104, or 75.1 per cent yielded an average initial production of 22.2 barrels each; 36, or 2.4 per cent, were gas wells; and 317, or 21.5 per cent, were dry. During the year 1916 there were 145 wells abandoned, as compared with 155 wells in 1915.

SOUTHEASTERN ILLINOIS

CUMBERLAND, COLES, CLARK, JASPER, AND EDGAR COUNTIES

Out of a total of 1,469 wells drilled in Illinois in 1916, there were 307, or 21 per cent, in the shallow-sand field. Clark County was by far the most active part of the shallow-sand field, with 256 wells completed, showing an average initial production of 14.6 barrels per well. The discovery of a new sand in the northern part of the Clark County field at a depth of 400 to 500 feet created great activity in drilling old wells deeper and sinking new ones between old locations.

The production at the north end of the Clark County field is from beds corresponding to the McClosky sand. It is a porous dolomite which varies greatly in its texture and consequently in its productivity from place to place. Its variable nature is well shown in areas where a vacuum has been used to increase production. New wells drilled between old locations frequently disclose the absence of any vacuum, whereas upon drilling the old wells deeper the vacuum is pronounced and even troublesome.

CRAWFORD COUNTY

In 1916 there were 568 wells drilled in Crawford County, as compared with 215 in 1915. Of the wells drilled in 1916 there were 391 which produced oil with an average yield of 15.5 barrels. Marked activity existed throughout the year in Honey Creek Township, where a number of good producers were drilled. In this area an initial production of 100 barrels was not uncommon. The production is from the Robinson sand which is extremely irregular in thickness and in character.

 TABLE 2.—*Fluctuation in prices per barrel of Illinois petroleum, 1916*

1916	Illinois	Plymouth
January 1	\$1.47	\$1.33
January 3	1.57	....
January 21 .....	....	1.38
January 27	1.62	1.43
February 16	1.72	....
March 6 .....	....	1.53
March 13.....	....	1.58
March 16.....	1.82	1.68
July 28.....	1.72	1.58
August 1.....	1.62	1.48
August 3.....	....	1.38
August 4.....	1.52	....
August 14.....	1.47	1.18
August 17.....	....	1.08
August 28.....	....	1.03
November 18.....	1.52	....
November 30.....	....	1.13
December 13	1.57	1.23
December 19	1.62	1.33
December 28 .....	....	1.43
December 29 .....	....	1.53
Average	\$1.64	\$1.38

LAWRENCE COUNTY

The favorable market stimulated drilling in the deep-sand field of Lawrence County, where 246 wells were completed in 1916 as compared with 157 in 1915. Of those drilled in 1916 there were 33 dry and the remainder had an average initial yield of nearly 45 barrels.

Drilling in the deep sands is expensive, especially with the prevailing high prices for material, but if oil continues to hold its present market value, much drilling will be done during 1917. The large number of sands in Lawrence County renders it extremely attractive to the oil operator.

The Ohio Oil Company wells, mentioned below, are among the best of those recently drilled in the county:

1. Clay Seed No. 2 farm, well No. 6, sec. 15, Lawrence Township; 310 barrels from Buchanan sand at 1,297 feet.
2. J. R. King No. 3 farm, sec. 13, Lawrence Township; 100 barrels from Kirkwood sand.
3. Wm. Buchanan No. 6, sec. 6, Dennison Township; 480 barrels from McClosky sand at 1,845 feet.

WABASH COUNTY

The Allendale field was the scene of considerable activity during the year; 29 wells were completed, 12 of which were dry. The average initial yield of the producers was 137 barrels, which was the best record of any Illinois field.

The present production comes from two sands—the Biehl above, and the Jordan which lies about 35 feet lower. The two sands occupy about the position of the Buchanan sand of the main fields, although it may be a new sand lying between the Buchanan and the Kirkwood. The Chester beds are thicker in Wabash County than in Lawrence County, and it is believed that the Kirkwood sand should be reached about 450 to 475 feet, the Tracey 575 feet, and the McClosky 700 to 750 feet below the top of the Biehl sand. These sands should be tested in the area of best present production, in other words, on the anticline.

The newer wells in sections 3 and 4 had an initial production of from 100 to 280 barrels.

SOUTH-CENTRAL ILLINOIS

MACOUPIN COUNTY

Six wells were drilled in Macoupin County during 1916. Of these, three are gas wells and the remainder are dry.

Arrangements were made for the commercial utilization of the Staunton gas, and a pipe line was laid connecting the field with Belleville, Edwardsville, Collinsville, Marysville, and Staunton. Wherever gas mains were available, they were utilized and the artificial plants rendered idle.

The owners of the field should have field tests made to determine the exact gasoline content of their product. The new absorption process of extracting gasoline from natural gas is commercially profitable with gas that contains as little as one pint to 1½ pints of gasoline per thousand cubic feet of gas. The gas associated with the oil at Staunton should be tested first, since it is likely to contain a larger amount of the lighter constituents than the gas from the dry sands on top of the dome.

CLINTON COUNTY

Drilling in Clinton County was confined mostly to inside locations in the Carlyle field and to the area near the Frogtown pool opened up at the close of 1915. In the latter area a few fair producers were drilled during the early part of the year, together with a number of dry holes. The oil sand is found at a depth of about 950 feet. Of the 33 wells drilled in the county, 22 were dry. The average initial yield of the producers was about 26 barrels.

The Flat Branch Oil Company drilled dry holes on the Philip Schafer farm in section 1, and on the H. Meyer farm in section 24, both in Wheat-field Township. The Bartelso Oil Company's test on the H. Varrell farm; section 1, Germantown Township, was dry at 1,045 feet.

MARION COUNTY

Interest was revived during the year in the Junction City dome where several sands are productive at shallow depth. The field lies about midway between Centralia and the Sandoval field.

The Dykstra sand lies about 560 feet below the surface or 20 feet below coal No. 6; the Wilson sand is 100 to 110 feet below the coal; and a lower sand produces in Tilton No. 1 at a depth of 160 feet below the coal.

The Stein and Benoist sands which produce oil at Sandoval and in the wells east of Centralia, should be tested in the Junction City dome. For this purpose a well should be located in the midst of the best shallow sand production. Stuart St. Clair of the Survey spent ten days in the Centralia area, and the results of his work are published in this bulletin.

During the year, 26 wells were completed in the county, 8 of which were dry. The average initial production was 12 barrels.

WESTERN ILLINOIS

No important developments featured the western part of the State in 1916. McDonough County fields were practically drilled up by the completion of 210 wells, 185 of which were producers with an average initial yield of 10 barrels.

After about 20 failures in Hancock County, where Roberts No. 1 was drilled early in the history of the field, Snowden Brothers found oil in hole No. 3 on the Charles Aleshire farm, sec. 24, St. Mary's Township. The pay sand is 11 feet thick at a depth of 360 feet. Aleshire Nos. 3, 4, and 5 had an initial production of 50, 25, and 20 barrels, respectively.

In attempts to extend the field 23 wells were drilled in the county during the year, but except for the wells close to the McDonough County line, all were failures.

A dry hole was completed in Schuyler County and two in Brown County.

The Ohio Oil Company drilled dry holes in sec. 6, New Salem Township, and in sec. 23, Beverly Township, both in Adams County. In the former, the lower 12 feet of the "Second lime" showed water and a very heavy oil characteristic of former wells drilled in the Pike County area.

In sec. 27, Washington Township, Pike County, a dry hole was drilled on the Goodrich farm.

Four dry holes were drilled in Henderson County, located as follows: sec. 12 and NW. $\frac{1}{4}$ sec. 8, T. 9 N., R. 4 W.; SE. $\frac{1}{4}$ sec. 17 and SW. $\frac{1}{4}$ sec. 22, T. 10 N., R. 4 W. One dry hole was drilled in Warren County on the Parrish farm, NW. $\frac{1}{4}$ sec. 34, T. 9 N., R. 3 W.

The results of the wildcat drilling in western Illinois served to emphasize the "spotty" character of the Hoing oil sand. So far as the Survey has been able to learn, no well outside the producing field has penetrated sand at the base of the Second (Niagaran) limestone. Despite this fact, one or two of the Henderson County wells had a show of oil or gas at the contact of the Second limestone and the underlying Maquoketa shale.

It is certain that favorable geological structure exists outside the Colmar-Plymouth fields, but the prevailing absence of the sand is a discouraging feature.

SOUTHERN ILLINOIS

During the summer the Survey maintained two parties in Saline, Williamson, Johnson, Pope, Union, and Jackson counties for the purpose of determining the geological structure of the region. Two prominent anticlines were mapped and described in Extract from Bulletin 35. Little is known regarding water conditions, but the possibility of locating the best structure in advance of drilling appeals to operators, since two or three wells, located properly, test the entire area, whereas a hundred holes, incorrectly placed, merely leave the question open.

Dry holes were drilled in Saline County as follows: center sec. 21, and NW. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 35, T. 10 S., R. 5 E.; NW. corner sec. 9, T. 11 S., R. 5 E. At the close of the year wells were being drilled in the SE. $\frac{1}{4}$ sec. 9, T. 10 S., R. 6 E., and in the SE. cor. sec. 33, T. 10 S., R. 5 E., the latter being the best location of any made, so far as structure is concerned.

NORTHERN ILLINOIS

In March, 1916, the presence of oil and gas was noted along a small fault plane in mine No. 7 of the Wilmington Star Coal Company, near Coal City. At the time of the writer's examination it was estimated that the flow of oil amounted to about two gallons per 24 hours, whereas the gas did not issue at a rate sufficient to burn continuously. The oil has a gravity

of 32° Beaumé, and the gas is of good quality. The oil and gas may have originated either in the Maquoketa shale, which underlies the "Coal Measures" in the region or in the Galena-Platteville ("Trenton") limestone, which lies directly beneath the Maquoketa shale.

In a shallow hole drilled in mine No. 7 sandstone 3 or 4 feet thick was found at a depth of about 20 feet below the coal. The fire clay under the coal and above the sandstone acts as an impervious layer and helps to seal the oil in the sandstone and to prevent its escape except along fault lines which afford channels upward.

A dome exists in secs. 35 and 36, T. 33 N., R. 7 E., and in secs. 2 and 11, T. 32 N., R. 7 E. It is not certain that any porous sandstones underlie the areas mentioned, but if they do, the tendency of any oil and gas in the vicinity would be to accumulate in the area where the rocks lie highest above sea level. A well located in sec. 35, T. 32 N., R. 7 E., was drilled to a depth of 101 feet. No sandstone was found, but gas was struck at a depth of 45 feet in limestone. No record is available as to the amount of flow, but presumably it was not enough to cause excitement at the time.

The top of the Galena-Platteville limestone lies not more than 200 to 250 feet below the surface on the dome. The Galena-Platteville itself should be penetrated in any attempt to test the area, but drilling in rocks below the Galena-Platteville would be useless. The geological structure of the area is mapped and described in a previous bulletin² of the Survey.

MISCELLANEOUS DRILLING

During 1916 scattered dry holes not mentioned above were drilled near Eldorado, Saline County; sec. 29, Mulberry Grove Township, and sec. 11, Mills Township, Bond County; sec. 13, Otego Township, Fayette County; near Campbell Hill, Jackson County; near Unity and Tamms, Alexander County; near Ullin, Pulaski County; and near Coal City, Grundy County.

SUMMARY TABLES

The following tables show the oil development in Illinois during 1916. The figures are compiled from the *Oil City Derrick* and the *Oil and Gas Journal* with additions by the author.

The total number of wells drilled to Jan. 1, 1917 was 25,323 of which 4,645 or 18.3 per cent were dry.

²Cady, G. H., Coal resources of District I: Illinois State Geol. Survey Coal Mining Series Bull. 10, 1915.

TABLE 3.—*Monthly record of wells drilled in Illinois, 1916*

Month	Completed	New production	Dry holes	Average initial production	Abandoned wells	Gas wells
		<i>Bbls.</i>		<i>Bbls.</i>		
January	93	984	33	16.4	14	7
February	82	1,105	23	18.8	16	6
March	119	2,339	29	26.7	5	3
April	93	1,056	22	14.9	7	1
May	169	2,678	38	21.1	5	4
June	184	2,828	43	20.1	36	6
July	142	2,647	25	22.6	10	1
August	156	2,957	32	23.0	5	2
September	142	2,700	28	23.7	10	1
October	103	1,862	32	26.3	17	3
November	110	2,478	24	28.8	6	1
December	66	1,134	14	21.8	14	0
Total.....	1,459	24,713	317		145	36
1915	756	14,055	197		155	18

TABLE 4.—*County record of wells drilled in Illinois, 1916*

County	Completed	New production	Dry	Gas	Abandoned
		<i>Bbls.</i>			
Clark	256	3,749	36	4	30
Cumberland	40	434	3	3	..
Crawford	568	6,071	151	26	64
Lawrence	246	9,540	33	..	47
Clinton	33	291	22	..	4
Marion	26	217	8	..	..
Wabash	29	2,325	12	..	..
McDonough	210	1,855	25	..	..
Hancock	23	167	10	..	..
Schuyler	1	..	1	..	..
Macoupin	6	..	3	3	..
Bond	2	..	2	..	..
Coles	11	57	5	..	..
Brown	2	..	2	..	..
Saline	3	..	3	..	..
Jackson	1	..	1	..	..
Fayette	1	..	1	..	..
Henderson	4	..	4	..	..
Warren ^a	1	..	1	..	..
Adams ^a	2	..	2	..	..
Pike ^a	1	..	1	..	..
Alexander ^a	1	..	1	..	..
Pulaski ^a	1	..	1	..	..
Grundy ^a	1	..	1	..	..
Totals.....	1,469	24,606	329	36	145

^aAdded by author.

PARTS OF SALINE, JOHNSON, POPE, AND WILLIAMSON COUNTIES

By Albert D. Brokaw

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INTRODUCTION

PURPOSE AND SCOPE OF REPORT

The area covered in this report lies in the southern parts of Saline and Williamson and in the northern parts of Pope and Johnson counties (fig. 1). It embraces the greater part of Tps. 10 and 11 S. and the north half of 12 S., in Rs. 2, 3, 4, 5, and 6 E. of the Third Principal Meridian.

The field work was done in June, July, August, and September, 1916, by the writer with the assistance of Mr. Horace A. Scott. The work is in the nature of more or less detailed reconnaissance, as the area to be covered (450 sq. mi.) and the lack of accurate maps precluded the possibility of detailed field work.

The report calls attention to the presence of two anticlines that appear to warrant conservative exploration. It is to be emphasized, however, that the uncertainties are great, even in the most favorable localities, on account of unknown faults which may break the reservoirs or restrict collecting areas, and because there may never have been important quantities of oil in the rocks of the region.

Since the relationship between geologic structure and oil accumulation has been so well established, the publication of an official report showing the existence of an anticline or a dome is the signal for wholesale leasing and drilling. Usually the resulting drilling far exceeds the amount necessary for proper tests. *Until oil has actually been found in paying quantity, all activities in leasing and in drilling must be considered extremely speculative.*

ACKNOWLEDGMENTS

The writer wishes to acknowledge the many favors granted and the courtesies shown by the residents of the region. For information he is especially indebted to Messrs. Hugh Murray, W. M. Page, Trammel and Joyner, and Dr. S. J. Blackman for maps, and other materials. The careful work of his field assistant, Mr. H. A. Scott, is also gratefully acknowledged.

GEOGRAPHY

TOPOGRAPHY

The northern part of the region is a lowland area, the elevations above sea level ranging from about 375 to 450 or 500 feet. It includes the broad alluvial plain of Saline River and its larger tributaries. Here and there shale hills rise above the general level, and throughout a large part of the lowland area the topography is gently rolling rather than flat. In southern Williamson County the terminal moraine of one of the earlier glacial epochs is found along the border of the lowland area.



FIG. 1.—Map showing area covered by this report.

The southern portion of the district is notably higher, the elevations reaching 800 feet above sea level. In the adjacent area to the east the maximum elevation is 1,060 feet above the sea, the highest point in southern Illinois. This highland area is often designated "a spur of the Ozarks", and the topography is not unlike that of part of the Ozark regions. The county is very rough—the stream valleys are deep and steep walled, the divides are commonly narrow, but in a few places are found broad, rolling uplands. A considerable portion of the upland area is forested. Numerous tracts have been cleared, and after a few years of cultivation have been abandoned to persimmon and sassafras. Roads are steep and rocky, since they must follow ridges or valleys more commonly than surveyed land lines.

The highland area is terminated on the south by an escarpment from 150 to 300 feet high, which forms the most striking and picturesque topographic feature of the area. The escarpment marks the boundary between the "sandstone country" of the upland and the limestone country to the south.

DRAINAGE

The northern portion of the area is drained chiefly by the tributaries of South Fork of Saline River. The northwestern corner is drained by Wolf Creek, a tributary of Big Muddy. The southern drainage is by tributaries of Lusk Creek, Bay Creek, and Cache River. In the smaller stream valleys striking scenic features are not uncommon; among the most widely known are the natural bridge on Hunting Branch southeast of McCormick; on Jackson Springs in sec. 31, T. 11 S., R. 4 E.; on Gum Springs in sec. 3, T. 12 S., R. 4 E.; on Leigh Falls in sec. 35, T. 11 S., R. 4 E.; and Fern Cliff, one-half mile southwest of Goreville.

TRANSPORTATION

Three railways cross the region: the Big Four through Carriers Mills, Stonefort, New Burnside, Parker, Tunnel Hill, and Sanborn; the Illinois Central through Willeford, Creal Springs, Parker, Ozark, and Simpson¹; and the Chicago and Eastern Illinois through Hudgens, Goreville, and Buncombe. The Chicago, Burlington and Quincy Railroad operates trains over the Chicago & Eastern Illinois tracks.

A number of postoffices in the area are situated at considerable distance from the railroads. With the exception of Eddyville, a thriving village of about three hundred inhabitants, these are very small communities, and accommodations for travelers are available only in private houses. The roads are rough, but during the summer and fall the main highways can be traveled by automobile. Automobiles are available at Harrisburg (seven miles north of Mitchellsville), Carriers Mills, Stonefort, New Burnside,

¹Simpson is $\frac{1}{4}$ mile south of the southern edge of the map, in sec. 22, T. 12 S., R. 4 E.

Creal Springs, Vienna (about 10 miles south of Tunnel Hill), at Marion (5 miles north of Hudgens) at Goreville, and at Eddyville. Eddyville may be reached by stage or automobile from Golconda.

STRATIGRAPHY

BEDS TO BE PENETRATED IN DRILLING

The beds with which the oil operator is concerned in the region under consideration include the Pottsville formation, the underlying Chester group of formations, and the Ste. Genevieve limestone. In terms of the well-known oil sands of southeastern Illinois, these beds include the horizon of the Bridgeport and Robinson sands at the top, and, in descending order, the Buchanan, the Kirkwood, the Tracey, and the McClosky sands. However, both the Pottsville and the Chester are very much thicker in the area described than in the main oil fields, and it is not to be expected that any one sand may be traced from the main oil fields to the southern end of the State.

It must be remembered that on the crests of the anticlines a large part of the Pottsville rocks have been eroded, and that the sands of the Chester group, together with the underlying Ste. Genevieve, offer the best opportunities for exploration.

In general, the Pottsville in the area under discussion consists of three heavy, cliff-making sandstones 75 to 150 feet or more thick, separated from each other by softer beds consisting of thinner sandstone, shale, and mixtures of the two. The latter beds weather into valleys and depressions, whereas the thick sandstone members stand out boldly as cliffs. The Pottsville is approximately 1,000 feet thick, but the uppermost part of the formation is not included in the graphic section, Plate I.

The Chester group consists of approximately 1,000 feet of limestones, shales, and sandstones. Four prominent sandstone formations are present in Pope County and should be represented throughout the area. The limestones and red shales are the most conspicuous features of the group. Drilling should penetrate the Ste. Genevieve in order to test the horizon corresponding to the McClosky "sand" of the main fields.

The graphic section (Plate I) includes the record of the Ohio Oil Co.'s J. H. Bynum well, sec. 35, Stonefort Township, Saline County, from the top of the well which is located at the base of the upper cliffmaking sandstone of the Pottsville to the base of this formation (see also figure 8). From a depth of 590 feet, or the top of the Chester beds, the section is from surface measurements and deep-well studies by Professor Stuart Weller.

The formation names in Plate I are tentative and are subject to revision.

ROCKS EXPOSED AT SURFACE

GENERAL RELATIONSHIPS

The surface rocks of the area comprise the lower portion of the "Coal Measures" known as the Pottsville series, a small area of glacial drift and loess, some alluvial deposits of Pleistocene age, and recent alluvial deposits in the stream valleys.

The Chester formations, which underlie the Pottsville series, outcrop to the south, and the overlying Carbondale formation outcrops to the north. The southern boundary of the Carbondale is the outcrop of coal No. 2 or Murphysboro coal. The Pottsville series may be defined as that portion of the "Coal Measures" below coal No. 2. The field work of the present report was restricted to the area immediately underlain by the Pottsville series.

POTTSVILLE SERIES

The Pottsville series of southern Illinois consists of sandstones, conglomerates, and shales, containing local "pocket coals" or nonpersistent coal beds and a very few thin limestones of local extent. The total thickness of the Pottsville is estimated at about 1,100 feet; the maximum measurement was obtained from the log of the Royse well, connected with a traverse from that point to the Henshaw mine, which is operating on coal No. 2; this gave a thickness of 1,060 feet.

A generalized cross-section, derived from a study of logs in conjunction with observations on the outcrop of the more resistant members is given below, numbered in order from the bottom up:

Generalized section of Pottsville series

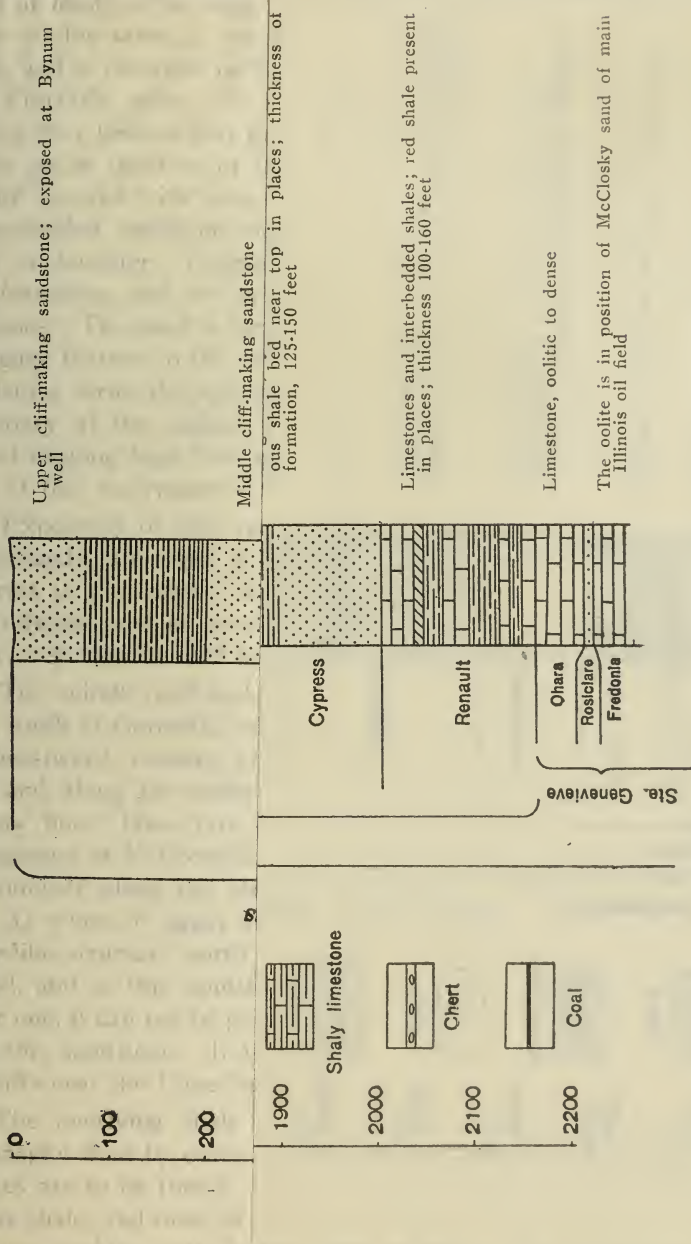
	Thickness Feet
7. Brown gritty shale.....	10-40
6. Lower cliff-making sandstone, massive cross-bedded sandstone with conglomeratic beds	100-250
5. Shale with thin micaceous sandy beds and local dirty coals.....	40-60
4. Middle cliff-making sandstone, massive, cross-bedded, quartzose sandstone with local conglomeratic lenses.....	40-150
3. Shale with thin sandy layers and local coal beds; one cannel coal....	75-125
2. Upper cliff-making sandstone, massive, cross-bedded sandstones not conglomeratic, commonly ironstained.....	100-200
1. Shales with thin beds of sandstone and sandy, micaceous shale; local limestones and coal beds; some gypsiferous shale.....	400

In western Kentucky the Pottsville series has been divided into the Caseyville sandstone and the Tradewater formations.² Apparently the for-

²Lee, Wallace, Geology of the Kentucky part of the Shawneetown quadrangle: Kentucky Geol. Survey, 1916.

ILLINOIS STATE GEOLOGICAL SURVEY

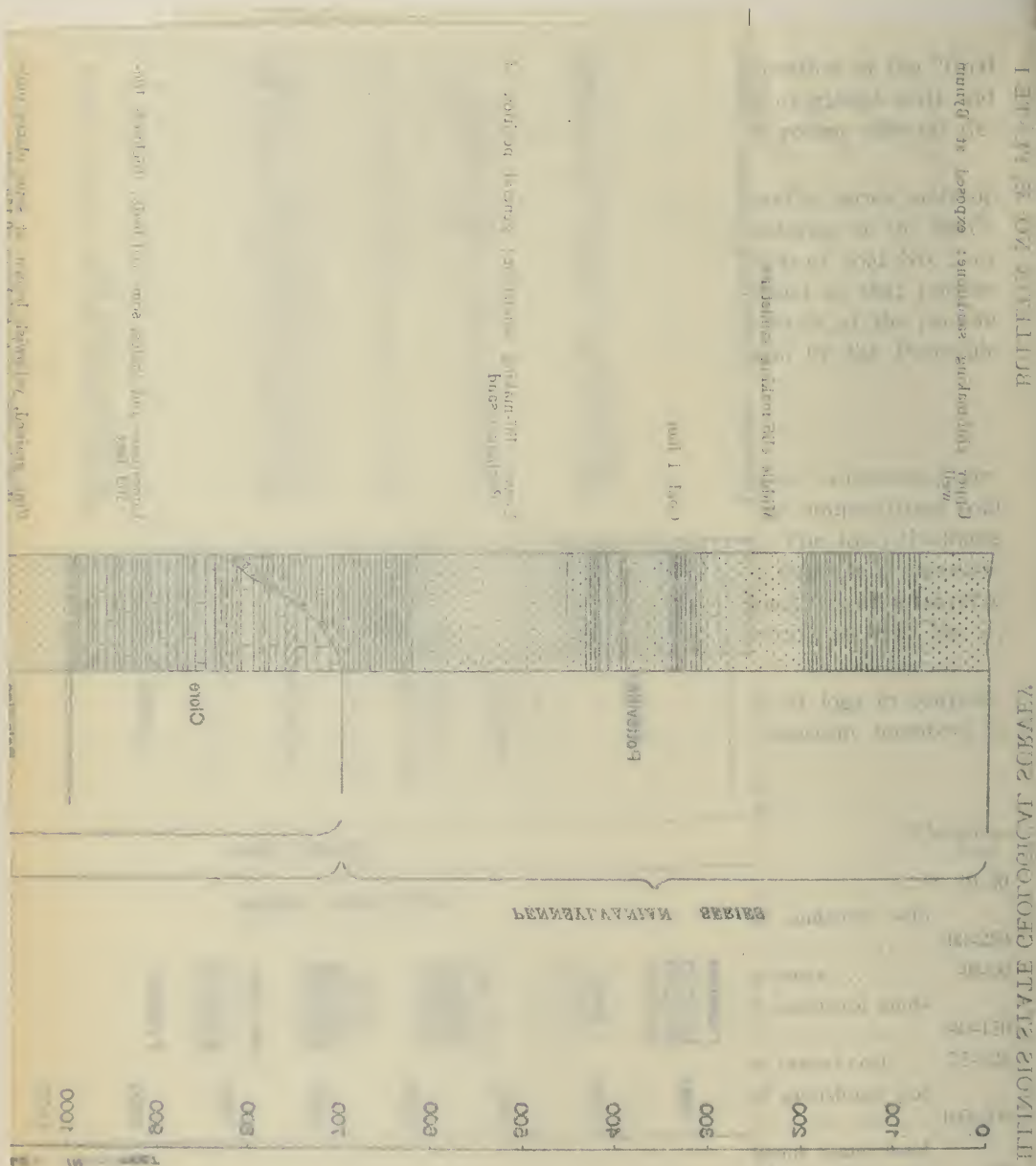
BULLETIN NO. 35, PLATE I



Graphic section showing beds to be penetrated in drilling

coal has been opened southeast of Ozark in secs. 35 and 26, T. 11 S., R. 6 E.

ROCKS EXPOSED AT SURFACE



Caseyville sandstone and the Tradewater formations. Apparently the 101

²Lee, Wallace, Geology of the Kentucky part of the Shawneetown quadrangle: Kentucky Geol. Survey, 1916.

mer corresponds approximately to the lower and middle cliff-making sandstones and the underlying shales, and the latter may be equivalent in part at least, to the upper sandstone and shales of the section. The basal shale of the series is exposed at a few points in the southern edge of the area, and is recorded in the logs of all wells which have entirely penetrated the Pottsville series. It is characteristically brown in color and in most places thin bedded and gritty. Exposures are not numerous, as the outcrops are at the foot of the southern escarpment and as the shale is commonly covered with talus. The lower cliff-making sandstone is a massive cross-bedded sandstone notably conglomeratic with pebbles less than an inch in diameter. Conglomeratic lenses are scattered irregularly through the formation, and are no more abundant near the base than at many other horizons. The sand is for the most part coarse, a quality that gives locally a sugary texture to the rock. Occasional grains of chert are found. This sandstone forms the bold south-facing escarpment which marks the southern boundary of the upland. It is a resistant rock, and a few outliers are found capping high hills south of the escarpment. The approximate position of this escarpment is shown in figure 2.

Exposures of the overlying shale are not abundant, but the area it immediately underlies is characterized by gently rolling topography in contrast to the rougher sandstone country. Such an area is found north of Eddyville, and in various other parts of the region. The shale is commonly reported in well logs, but its thickness varies considerably.

The middle cliff-making sandstone is typically developed at Buffalo Gap, south of Goreville, where it forms a low escarpment. It may be traced southeastward, running from a little south of Sanborn through Moccasin Gap and along the north flank of the McCormick anticline to the Pope County line. Here this sandstone is buried under later formations, but it reappears at McCormick in the head of Ogden Hollow and may be traced continuously along the McCormick anticline to a point south of Colorado (fig. 3) where it again disappears, to reappear in the flank of the small dome-like structure north of Delwood. Farther east exposures are interrupted, and as this sandstone can not be definitely distinguished from the lower one, it can not be positively stated which outcrops are to be correlated with this sandstone. It is believed to be the sandstone forming most of the cliffs near the Pope-Saline County line.

The overlying shale is again evidenced more commonly by rolling topography than by outcrops, though a large number of rather limited exposures are to be found. Coals of local extent are found in various parts of this shale, and most of the coal banks or small local mines in the Pottsville are working coals in this shale member. One 40-inch bed of cannel coal has been opened southeast of Ozark in secs. 35 and 26, T. 11 S., R. 6 E.

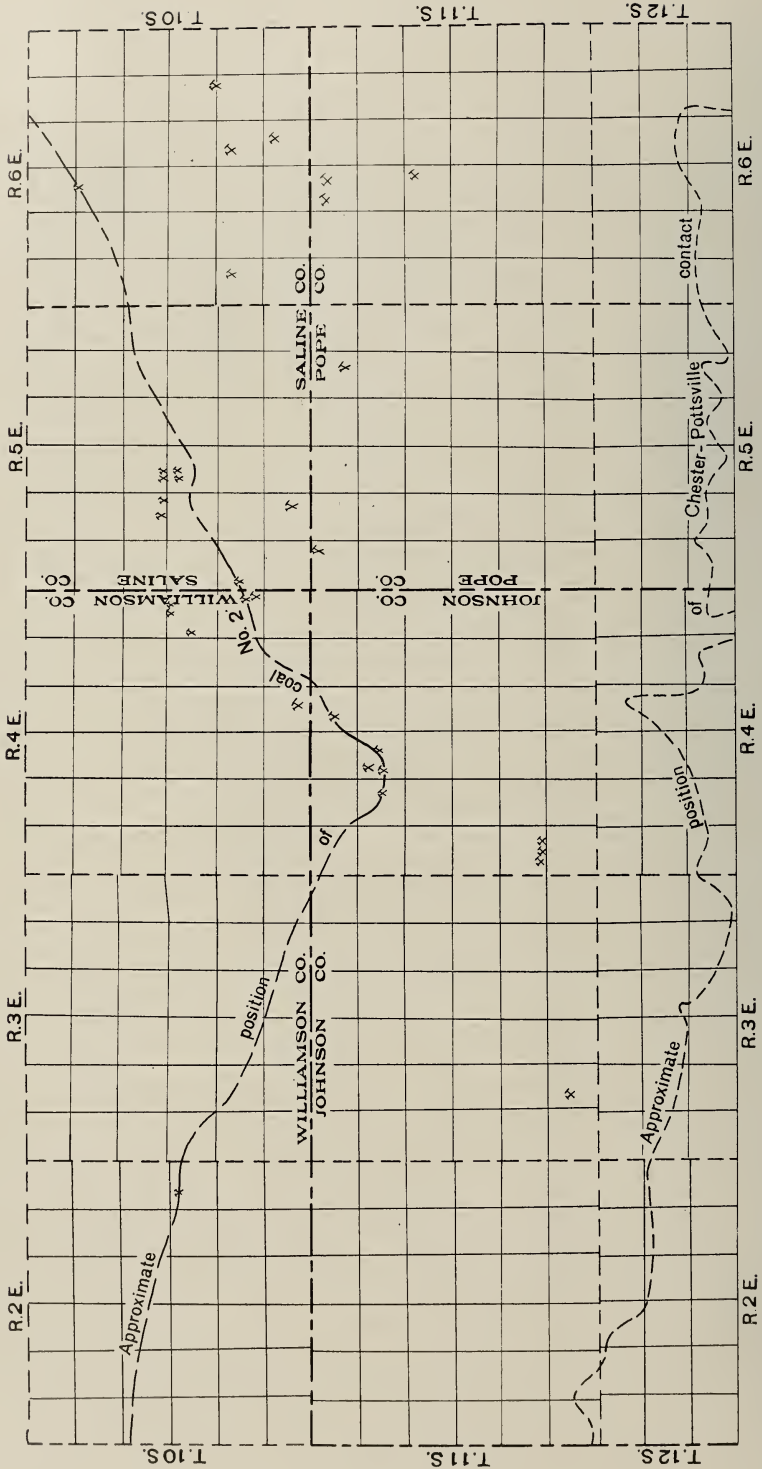


FIG. 2.—Map showing the approximate position of the outcrop of coal No. 2 and the position of the Chester-Pottsville contact.

The top of the shale is exposed in the south end of the tunnel at Tunnel Hill, where it is overlain by the lower part of the upper cliff-making sandstone.

The upper cliff-making sandstone is exposed in the walls of Sugar Creek at Parker. The lower portion is a rather thin-bedded, dense, fine-grained, brown sandstone that grades upward into coarser cross-bedded sandstone closely resembling the non-conglomeratic phases of the lower



FIG. 3.—Concretionary iron bands in middle cliff-making sandstone, sec. 7, T. 11 S., R. 6 E.

sandstones. At Parker the sandstone is nearly 200 feet thick, but considerable variation in thickness is shown in logs of drilling holes and at exposures. The formation is exposed here and there along the New Burnside anticline. It forms the striking ridge at the Bynum well, and is thought to form the steep bluffs along Creed Creek at least as far east as

sec. 32, T. 10 S., R. 6 E. It may possibly be correlated with the sandstone high up in the walls of Mud Spring Hollow in sec. 35, T. 10 S., R. 6 E. Figure 4 is from this locality.

North of the exposures of the upper cliff-making sandstone the topography is characteristically rolling, and most of the outcrops are shale or thin-bedded, friable sandstones usually in very limited exposures. The thickness of this formation, which is predominantly shale is estimated at 400 feet. This upper shale includes a few local coal beds, and thin local limestones. From one locality gypsum flakes in the shale were reported.



FIG. 4.—Cross-bedding in Pottsville sandstone in east bank of Mud Springs Hollow, sec. 35, T. 10 S., R. 6 E.

The bluffs west of Stonefort and at Bald Mountain, northeast of New Burnside, are tentatively referred to a lens of sandstone at or near the top of the Pottsville series.

CARBONDALE FORMATION

Coal No. 2, or Murphysboro coal, is the basal member of the overlying Carbondale formation. In this region it consists of two 36-inch coal seams separated by 15 to 25 feet of shale. The parting thins to the west, and at Murphysboro it is not noted. Farther east the two seams are said to be 40 feet apart. Exposures are not abundant, but the probable outcrop was traced by locating old workings many of which are caved and inaccessible, and by the few active local mines on one or the other

of these seams. What is believed to be coal No. 2 was traced from the hills northwest of Mitchellsville to the point where the Big Four crosses the South Fork of Saline River, thence southwestward to a point $1\frac{1}{2}$ miles west of New Burnside. From this point the outcrop swings northward and is shortly covered by glacial drift. A coal mined $1\frac{1}{2}$ miles southeast of Hudgens is thought to belong to the same horizon. No exposures were found within the area west of this point, but an 8-foot bed is reported in sec. 8, T. 10 S., R. 1 E., which may be coal No. 2.

GLACIAL DRIFT

The southern limit of glaciation is near the Williamson-Johnson county line. Drift was observed as far south as the north side of sec. 12, T. 11 S., R. 2 E. In Saline County the drift has not extended so far south as in Williamson and Johnson counties, and the terminal moraine was not followed. Near the Williamson-Johnson County line few large boulders were seen, but igneous pebbles are abundant. Owing to the deep mantle of drift in this vicinity rock outcrops are very scarce.

South of the drift-covered area in many places the upland soils consist of yellow, fine-grained, gritty material designated as "yellow silt loam" by the Soil Survey. This material is believed to be in part loess. In the upland area of Johnson County this type is probably more common than residual soil.

OIL AND GAS

RELATION OF GEOLOGIC STRUCTURE TO OIL AND GAS ACCUMULATION

The following paragraphs on theories of oil and gas accumulation will aid the reader in understanding the significance of the structures to be described.

Petroleum and natural gas have been so commonly found in anticlinal structures, as shown in figure 5, that it is generally conceded that such structures offer the best situation for test wells, and the search for and study of such structures have come to be the accepted method of the petroleum geologist. This is particularly true for rocks saturated with water. If oil and water occur in the same sand, the oil is always found above the water. It is evident that in an anticline in which an impervious stratum lies above an oil sand, the oil, being lighter than the water, tends to accumulate at the crest of the fold. Gas, if present, actually occupies the crest, below it is the oil, and still lower, water—usually salt water (fig. 5, A).

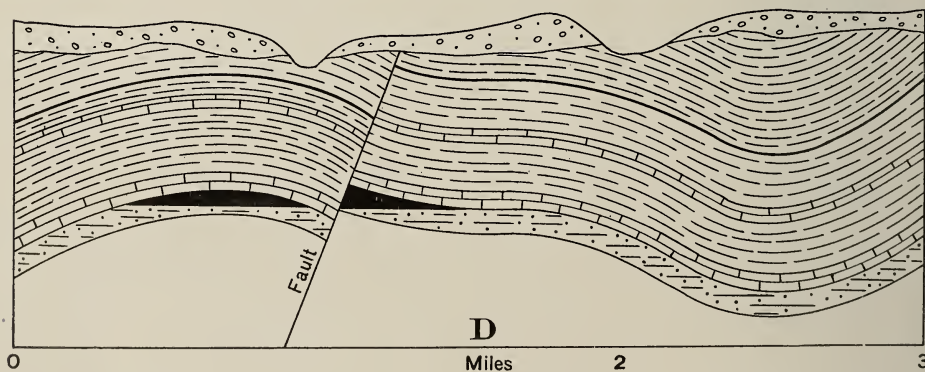
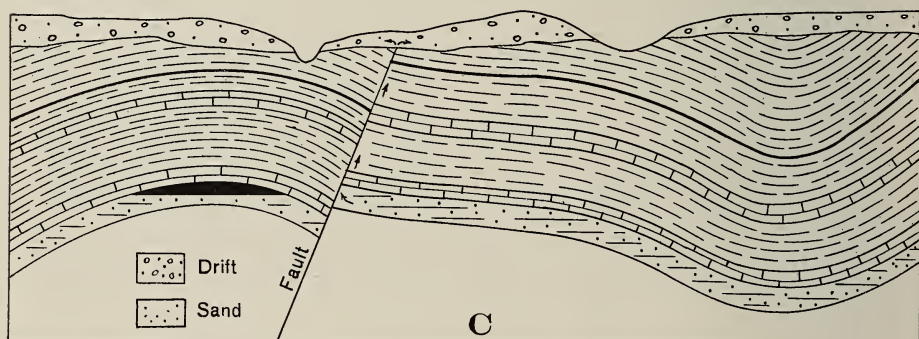
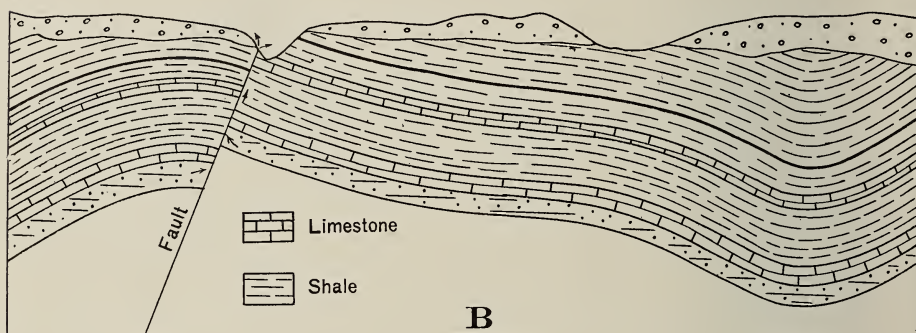
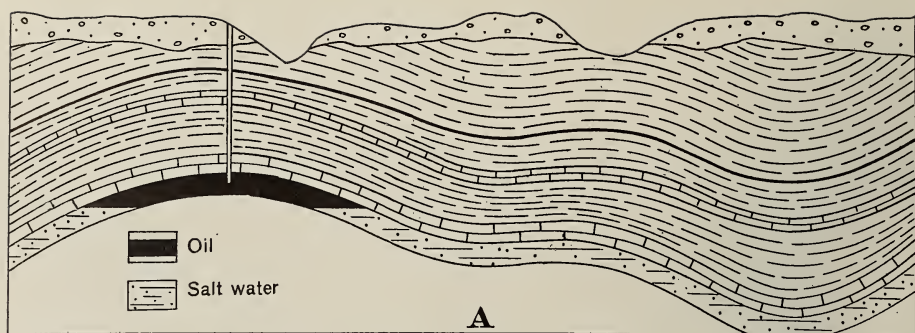


FIG. 5.—Diagrammatic cross-sections showing effect of geologic structure on oil accumulation. In B and C the fault plane is supposed to afford a channel by which the oil has escaped, whereas in D, impervious material fills the fault and provides an effective seal.

Three important conditions must be fulfilled if oil is to accumulate in commercial quantities in anticlines:

1. The rocks (or sandstones) that contain the oil must be saturated with water, as the oil will rise in the rocks only so far as it is buoyed up by the underlying water. If the rocks are dry the oil will sink until it rests on water, or on an impervious stratum. It may even be in the base of a syncline.
2. The anticline must be tight. That is, it must contain a relatively impervious layer above the oil sand, and must not be seriously broken by faults which would allow the oil to escape (fig. 5, B).
3. There must be a collecting area of sufficient size to supply a considerable amount of petroleum. The oil was doubtless originally dispersed through a large area, and has later collected in pools. In a given pool the amount of oil may depend directly upon the collecting area.

In a prospective region the presence of anticlines is of great importance, but the amount and character of faulting and the location of faults is no less important. The effect of faults in producing leaks in the structure has already been mentioned. A fault below the crest of an anticline may cut off, or seriously restrict the collecting area, and allow only small amounts to accumulate (fig. 5, C).

Sealed faults—that is, faults so completely filled with impervious material as to offer no avenue of escape for oil—may in some cases afford important places for the accumulation of oil and gas (fig. 5, D).

Some important oil fields have been located where no structural conditions would suggest the probability of oil, and no doubt others will be found, but in the majority of cases accumulation is found to be definitely related to structural features. For this reason knowledge of the geological structure of a prospective oil region is eminently desirable and may save a great deal of unnecessary drilling in unfavorable localities. If oil or gas is not found in the anticlines, the chance of finding them elsewhere in the region is comparatively small. On the other hand, any number of dry wells drilled off the favorable structures may give no information as to the presence or absence of oil in the region.

STRUCTURAL FEATURES OF AREA

GOLD HILL FAULT - *Saline Hill Fault*

The Gold Hill fault in the area to the east is probably the most striking structural feature of southern Illinois. It involves beds of Pennsylvanian and Mississippian age in a vertical displacement estimated at 1,000 to 1,500 feet, and forms the conspicuous range of hills known as Gold Hill and Cave Hill.

In discussing this fault in connection with early studies of the region, Cox³ says, "Though the Gold Hill fault disappears beneath the lowlands

³Cox, E. T., *Geology of Saline County: Geological Survey of Illinois vol. 6, p. 220.*

west of this hill, it is seen again as a conspicuous ridge of massive conglomeratic sandstone in the southwestern part of the county near the village of Stone Fort⁴". He further notes that "the strata here present the appearance of an anticlinal axis". The correlation of the structures in this region with the Gold Hill fault is one which readily suggests itself, but proof is lacking, as it is impossible to trace the effects of the eastern disturbance into the region covered in this report.

MCCORMICK AND NEW BURNSIDE ANTICLINES

Two well-marked anticlines, traceable for a number of miles, are the important structural features of the region. Both have a general southwest-northeast trend, swinging to a nearly east-west direction in the eastern part of the area. They have been designated the McCormick and New Burnside anticlines, from localities on or near their respective crests (see Plate II).

The McCormick anticline was traced from the vicinity of Gum Springs, about two miles north of Simpson, northeastward across secs. 10, 3, and 2, T. 12 S., R. 4 E.; 35 and 36, T. 11 S., R. 4 E.; 31, 30, 29, 20, 16, 15, 10, 11, 12, and 1, T. 11 S., R. 5 E.; 6, 5, and into 4, T. 11 S., R. 6 E.

The anticline is in general not symmetrical, but has its steeper dip, ranging up to 50 degrees, on the north limb. The southward dips are rarely over 20 degrees. At Gum Springs a well-marked fault was noted in the north flank about 300 yards north of the crest of the fold. The fault brings up gently north-dipping Chester limestone and shale into contact with the Pottsville sandstone and conglomerate having a northwest dip of 50 degrees (see cross-section A-A, Plates II and III). This fault probably persists along the anticline at least into sec. 35, T. 11 S., R. 4 E., where Chester limestone is found in the bottom of a stream valley near the crest of the anticline. There is also evidence of faulting west of Flat Rock schoolhouse, where a nearly vertical dip was observed. In sec. 4, T. 11 S., R. 6 E., and eastward, considerable faulting has occurred, but in the rest of the structure no positive evidence of faulting was found.

The New Burnside anticline extends from Parker northeastward through secs. 17, 16, 9, 10, 3, 2, and 1, T. 11 S., R. 4 E., into sec. 6, T. 11 S., R. 5 E., where the structure is apparently interrupted, but possibly continued along the south side of secs. 6, 5, and part of 4. It is then resumed in the north part of 4, extends through 3, T. 11 S., R. 5 E., 34, 35, and 36, T. 10 S., R. 5 E., and with possible interruptions through 31, 32, and 33, T. 10 S., R. 6 E. Southwest of Parker the anticline widens and flattens. It extends through secs. 18 and 19, T. 11 S., R. 4 E., and 24 and 23, T. 11 S., R. 3 E., beyond which the structure gradually disappears under the influence of the broad uplift to the southwest.

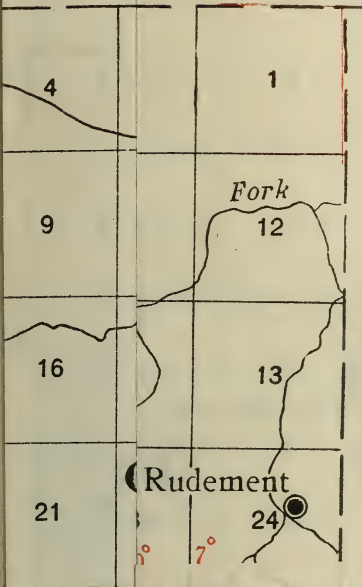
⁴The "Old Town", as it is now called, is located about $2\frac{1}{2}$ miles southeast of the present village. To this, rather than the present village, reference is made.

BULLETIN NO. 35, PLATE II

R.4

LEGEND

- County line
- Township line
- +---+---+--- Railroad
- Town



T.10 S.

8°
↑

Direction of dip is shown by the arrow, the strike by the straight line perpendicular to the arrow, and the amount of dip by the figure.

Scale of

1:152

R.S.E.



102

102

Some indications of continuation of both structures to the east were noted, but considerable faulting on a small scale at least, is evident (fig. 6), and this easternmost area is believed to be unpromising.

With the exception of these two anticlines and the faulted area in the eastern portion, the structure of the region is gently north-dipping—in general, northwestward in the eastern part and northeastward in the western part, with gentle undulations but no reversed dips. No effort was made to trace the McCormick anticline into the limestone area to the south, but the fact that it extends into that area was established.



FIG. 6.—Steeply tilted beds in faulted contact with gently dipping beds in Dog Hollow, NW.¼ sec. 11, T. 11 S., R. 6 E.

RECOMMENDATIONS FOR FUTURE DRILLING

The general northward dips indicate that the collecting areas for the two anticlines are chiefly north of the axes, and it is at once evident that the New Burnside anticline has a very much greater collecting area than the McCormick. This fact, and the presence of known faults in the latter, make the New Burnside anticline the more favorable of the two, though the unfaulted portion of the McCormick anticline may yield important developments. Indeed it is possible that the faulting may not be sufficient to seriously affect the structure, but the probability is against this. The apparently large collecting area of the New Burnside anticline may be less than it appears to be, as it is possible that the strong Gold Hill faults extend

through the area north of the anticlines, but can not be found because of the thick cover of silt in the broad valleys of Saline River and its tributaries. Such faults may so seriously restrict the collecting areas as to prevent the accumulation of commercial quantities of oil in the anticlines.

In testing the field, wells should be located near the crest of the anticlines, preferably a little south of the crest, because of the steeper dips on the north limb. (See figure 7 and Plate II.) The areas believed to be most favorable for drilling have been outlined on the map. Topographic conditions must, of course, be taken into account, but in general the possibilities of a field are most surely determined by drilling the proper structures, without reference to topography.

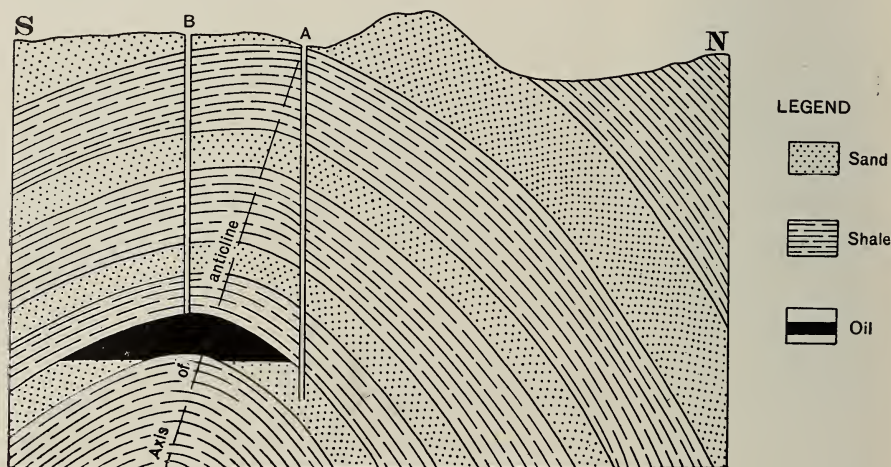


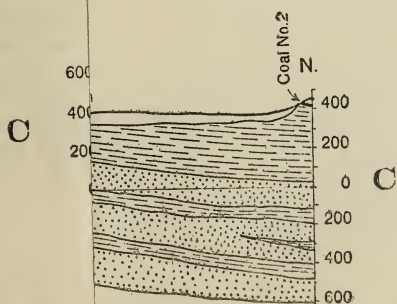
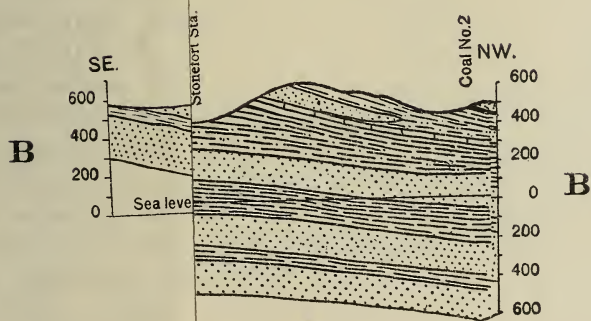
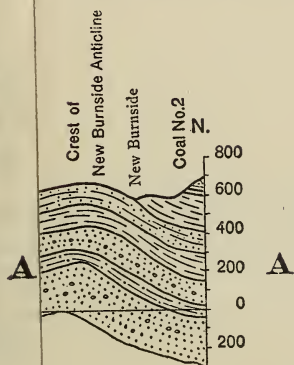
FIG. 7.—Diagrammatic cross-section showing proper location for test well on an unsymmetrical anticline.

In studying structures with a view to testing the area for oil it is important to locate any domelike portions of the anticlines, which should in general be more favorable than other points along the crest of the structure. Where possible it is desirable to construct structure-contour maps, but in the present work the inaccuracy of the maps available and the lack of any means of accurately determining levels would not justify the attempt.

Two methods for determining domelike areas presented themselves.

1. To determine altitudes along the crest of the anticline and location in the sections; then by assuming an average thickness for underlying formations estimating the altitude of the base of the Pottsville series.
2. To study the data assembled on the map with reference to areas from which the direction of dip is roughly radial; such an area will be seen on the map in secs. 5 and 6, T. 11 S., R. 6 E.

The first method was attempted in the field, but the results are far from satisfactory. The difficulty of determining the position in the section



with any accuracy was almost insuperable; add to that the known variability in thickness of the underlying beds and the inaccuracies of barometer determinations, and it will be seen that the results are no more than an extremely rough estimate. The general result of these studies indicated that both structures plunge gently eastward, but undulations along the axis could not be established.

The second method strongly suggests a dome in secs. 5 and 6, T. 11 S., R. 6 E., as mentioned, one in secs. 33 and 34, T. 10 S., R. 5 E., and secs. 3 and 4, T. 11 S., R. 5 E., and less strongly suggests one south of Parker in sec. 17. Similar structures are vaguely suggested at various points along the crests of both the McCormick and New Burnside anticlines in sec. 10, T. 11 S., R. 5 E.

LOCALITIES ALREADY TESTED

It is stated by Mr. J. E. Joyner of Stonefort, Illinois, that in drilling a well some twenty years ago, on what is now known as the Royse farm, in sec. 21, T. 10 S., R. 5 E., a flow of oil was struck at about 180 feet. The oil is said to have flowed for several hours, but as water was desired, drilling was resumed and when water was struck the well was pumped out. At the time the writer visited the well no evidence of oil was seen. A test well drilled on the same farm in the summer of 1916 yielded salt water, but no indications of oil.

The Warren well in sec. 3, T. 10 S., R. 6 E., was drilled for oil (fig. 8), and at 1,120 feet small amounts of gas and oil were struck with a flow of fresh water. Drilling was continued to 1,716 feet, where salt water, but no oil, was obtained. The salt water was shut off, and at present the well is flowing, yielding fresh water, with occasional gas bubbles and a very small amount of oil, not more than a few ounces per day.

Dry holes have resulted from drilling at the following points:

Bynum farm, sec. 35, T. 10 S., R. 5 E. (fig. 8).

Royse farm, sec. 21, T. 10 S., R. 5 E. (fig. 8).

Reeves farm, sec. 15, T. 11 S., R. 4 E.

Allen (?) farm, sec. 4, T. 10 S., R. 2 E.

One reported from near Creal Springs, sec. 17, T. 10 S., R. 2 E.

Wells are now being drilled at the following points:

Sec. 9, T. 10 S., R. 6 E.

Sec. 23, T. 10 S., R. 5 E.

Sec. 9, T. 11 S., R. 5 E.

Practically all the dry holes ended in salt water, which is almost uniformly present in the deeper strata, and is not uncommonly encountered in the Pottsville sandstones.

With the exception of the Royse and Warren wells (fig. 8), the writer has no information of oil having been struck in wells, nor has he seen any oil seeps or other surface indications of oil.

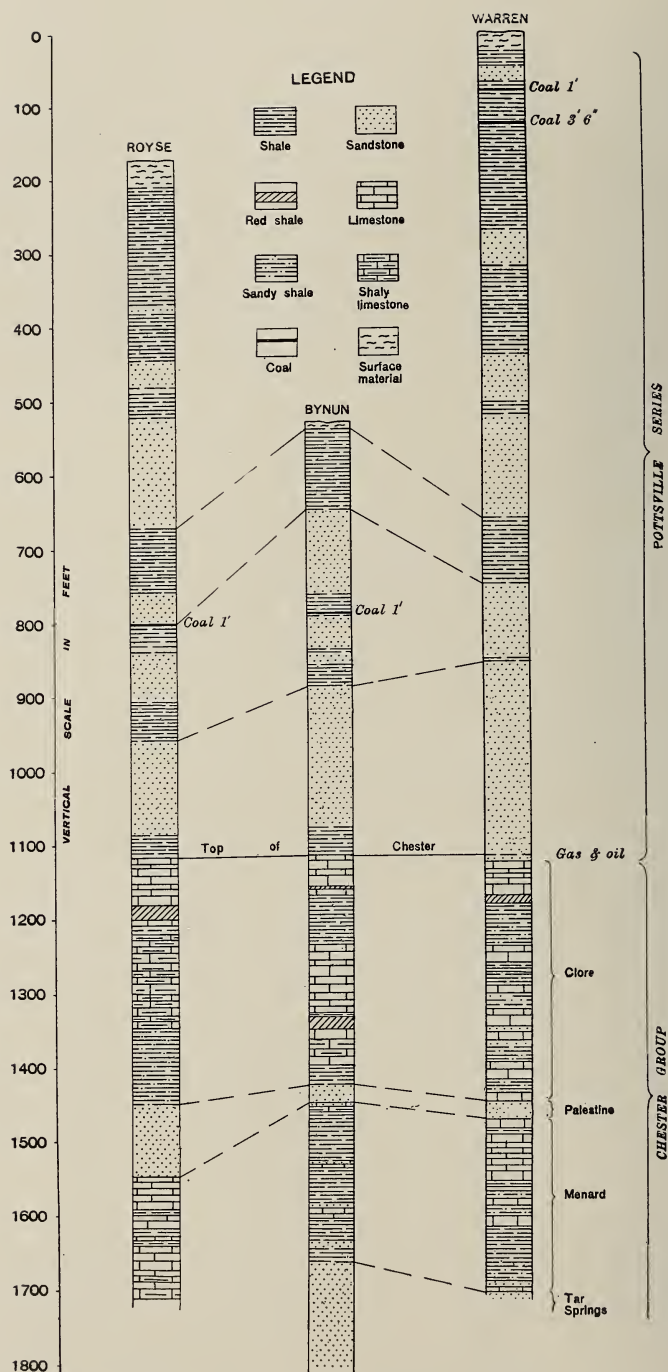


FIG. 8.—Graphic sections of the Royse, Bynum, and Warren wells.

The fact that the strata which are oil bearing in the main Illinois fields underlie the Pottsville rocks of this area would seem to justify a reasonable amount of prospecting, and it is to be noted that none of the holes so far completed are in reality favorable locations with reference to the structures. The well in sec. 9, T. 11 S., R. 5 E., and especially the one in sec. 33, T. 10 S., R. 5 E., are in much more favorable locations and may yield important information.

One adverse feature has been pointed out by Professor Stuart Weller⁵. It is his opinion that several of the important oil sands in the eastern Illinois fields are lenticular sandstones in the Renault formation. In southern Pope County the corresponding formation consists entirely of massive limestone, which would not offer a favorable reservoir for the accumulation of petroleum. It is highly probable that this character of the Renault formation persists under the Pottsville series of this region.

⁵Oral communication.

PARTS OF WILLIAMSON, UNION, AND JACKSON COUNTIES

By Stuart St. Clair

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INTRODUCTION

AREA COVERED BY REPORT

The area treated in this report lies wholly within southern Jackson, northern Union, and western Williamson counties. This area is shown in figure 9. A line drawn southeast from Murphysboro through Carbondale and on into Williamson County through Cottage Home and Wolf Creek to the county line, south along the Union-Johnson County line for about nine miles to Cache River valley, from there northwest through Cobden and Alto Pass to the county line, thence north to Land Ridge and northeast to Murphysboro would accurately outline the area studied.

RECONNAISSANCE METHODS

The report is the result of about eight weeks of reconnaissance work in the southern part of Illinois, and points out the position of a low anticlinal fold which was traced for eight miles, a low irregular dome structure which covers approximately five square miles, and a terrace structure which may have possibilities. The writer was assisted in the field work by Mr. Marvin Weller. The maps used were United States post office maps of Jackson, Williamson counties and a land survey map of Union County.

The object of the work was to make a reconnaissance examination of the assigned territory to determine the general structure and to map the position and extent of any area where structural irregularities were developed to such a degree that the accumulation of oil, in so far as structure is a factor in this process, might at least be a possibility. From the character of the work done and the almost total lack of past prospecting the writer is able only to call attention to limited areas where there are some possibilities, and negatively to show the much larger area, where probabilities of oil accumulation in commercial pools are entirely lacking.



Fig. 9.—Map showing area covered by report.

GEOGRAPHY

TOPOGRAPHY

The lowest point in this area is found in the northwest corner where the valley bottom of Muddy River is about 370 feet above sea level. Other low areas are in the drainage basins of Muddy River on the north and Cache River on the south. In these the low points range close to 400 feet above sea level.

The high points are along the divide which crosses northern Union County and which separates the Muddy basin from the Cache basin. This divide ranges from 840 feet above sea level on the west to about 750 feet on the east. Bald Knob, the highest point in the immediate region, is in the extreme southwest part of the area. Aneroid measurement based on the railroad bench mark at Alto Pass credits the Knob with an elevation of 1,050 feet.

The extreme northern part of the area is level prairie land so typical of the greater part of the State. Southward this merges gradually into a gentle hilly country broken by deep ravines and in places steep slopes. The original topography of this northern portion of the area has been greatly altered by a covering of glacial drift and wind-blown loess, the thicknesses of which are variable. South from this glacial boundary the country is much more rugged, the hills are higher, and the immediate relief is greater. The rough country terminates with the divide which irregularly crosses the northern part of Union County. The divide is formed by the northward-dipping beds of the lower Pottsville sandstone. Long spurs (fig. 10) of this rugged formation extend southward into a rolling country, giving a very serrate contour to the divide. The reentrants between these arms are a rolling country that is in marked contrast with the rougher hills.

South of the distinctive Pottsville topography and in the extreme southern and southeastern part of the area the country is rolling.

DRAINAGE

The master streams of the area are Muddy River on the north, with Cedar and Crab Orchard creeks as main tributaries and Cache River on the south with Lick and Bradshaw creeks as tributaries.

CULTURE

The principal towns in the northern part of the area are Murphysboro, which is a center for the Mobile and Ohio Railroad, Illinois Central Railroad, and St. Louis, Iron Mountain, and Southern Railway; Carbondale, a railroad center for the Illinois Central Railroad branches; and Carterville on the Illinois Central Railroad. The principal towns in the southern part are Anna with Illinois Central Railroad connections and Jonesboro on the Mobile and Ohio Railroad, although Cobden and Alto Pass are centers for large fruit shipments.

The chief agricultural products of the country are fruits and sweet potatoes in the hilly country, and grains in the lower and rolling parts of the area. A large part of the area is too rough to utilize except for grazing purposes.

STRATIGRAPHY

GENERAL RELATIONSHIPS

The consolidated rocks of the area belong to the Carboniferous system, the lower half of the Pennsylvanian and the upper half of the Mississippian series being represented. Overlying the consolidated rocks are the uncon-



FIG. 10.—Pottsville escarpment east of Lick Creek, Union County.

solidated deposits of the Quaternary comprising glacial drift, fluvio-lacustrine deposits, loess, and alluvium. A graphic section showing the succession of formations and their general characteristics is given on Plate IV.

QUATERNARY DEPOSITS

ALLUVIUM

Flood plains are present along most of the streams in the area. The deposits are usually made up of silt and clay with some sand. In the hilly part the alluvium along the streams is composed of coarser material, sub-angular pebbles of sandstone and shale, sand, and silt.

VALLEY DEPOSITS

In the valleys of the master streams are deposits of fluvio-lacustrine material of two ages. The lower and younger deposit consists chiefly of greenish-gray to purple clay, the upper part being concretionary. A little sand is present in places.

The earlier and topographically higher valley fill is composed of clay and fine sand. This deposit forms two fairly well-defined terraces, the tops of which are about 410 and 390 feet, respectively, above sea level.

LOESS

Deposits of loess are found scattered irregularly over the area, being thicker near the main streams and Mississippi River than in the hills in the interior of the area. The loess is a fine-grained, massive earth or loam of yellowish to brownish color and is usually calcareous. A characteristic weathering feature of the loess is its steep and even cliff-like faces which may rise from a few feet to as much as 20 feet. The loess on the hills is of wind-blown origin.

GLACIAL DRIFT

The boundary of the glacial drift is approximately shown on the map, Plate V. The drift varies in thickness from place to place, and has been entirely eroded in some localities. Where the drift is thick the typical topography of the underlying rock formation has been greatly altered and the ledge outcrops are covered except in some stream valleys.

The drift is composed of clay and pebbles, and decayed boulders of varying sizes. The pebbles and boulders are of many kinds of rock, some entirely foreign to the region. A few glacial boulders were found on the tops of the hills as far south as the Union County line.

CARBONIFEROUS SYSTEM

PENNSYLVANIAN SERIES

CARBONDALE FORMATION

The Carbondale formation is the youngest consolidated rock formation found in the area covered by this report. Its upper limit is defined by the top of coal No. 6; the lower limit, by the floor of coal No. 2. The formation is composed essentially of shale containing thin interbedded sandstones. Some limestone lies in the upper part, one bed being above coal No. 5, which is approximately 40 feet below coal No. 6 in the immediate region; a second limestone is a little below coal No. 5. A persistent sandstone which is 30 feet or more in thickness is found about 20 feet above the upper bench of coal No. 2. Coal No. 2 is divided into two benches separated by a shale parting of variable thickness; at one place near Murphysboro it is only a few feet thick; a mile southeast of Carbondale it has increased to 20 feet; and at the local mines $3\frac{1}{2}$ miles southeast of Carbondale the parting has increased to 30 feet in thickness.

Topographically the Carbondale area is level to slightly rolling with a few scattered hills which are caused by more resistant sandstone beds.

POTTSVILLE FORMATION

The Pottsville formation is composed of thick, cross-bedded sandstone and shale members interbedded with thinner sandstones and shales. A few irregular and discontinuous thin coal beds lie at various stratigraphic posi-

tions. The irregularity of the strata and the frequent lateral gradations of shale and sandstone made it impracticable to compile an accurate section. No accurate measurement of the Pottsville formation was practicable in the area. A drill record north of Carbondale shows a thickness of 676 feet. Northwest of Murphysboro the formation in places does not exceed 420 feet in thickness. East of the area covered by this report, in northern Johnson County the Pottsville attains a thickness of approximately 1,000 feet.

In the northwestern part of the area the upper 20 to 30 feet is sandy shale underlain by sandstone. In the eastern part of the area this upper shale member thickens materially, probably attaining a thickness of 100 feet or more. Below this are no distinctive members in the formation except in the vicinities of Pomona and especially Makanda, and in the southern part of the area. At the first two places a heavy cliff-forming sandstone is present, the base of which is probably about 100 to 150 feet above the base of the Pottsville. Locally, just south of Makanda, a thin, irregular coal bed is near the base of this member. The sandstone exposure near Makanda is over 100 feet. In the southern part of the area the base of the Pottsville is distinctive, being a heavy and at certain horizons a conglomeratic, cliff-forming sandstone which varies in thickness from 30 feet in the west to over 100 feet in the hills east of Lick Creek. This basal member is responsible for the long Pottsville arms which protrude south into the Chester area.

Between 50 and 60 feet below the top of the Pottsville occurs a lenticular coal bed which has been mined in several localities. Two miles southwest of Murphysboro the coal is three feet thick. Four miles southeast of Carbondale 8 feet of coal is reported in a drill hole, 50 feet below the lower bench of coal No. 2. Other lenticular but thin coal beds outcrop at several other lower positions in this formation.

The Pottsville rests unconformably upon the Chester. One of the causes of variation in thickness of the Pottsville is the irregular surface upon which the basal sediments were deposited. The possibility of accumulation of oil and gas in certain sandstone horizons of the Pottsville where structural conditions are favorable is of economic interest and importance. In the Lawrence County field the Buchanan sand is in the basal part of this formation.

MISSISSIPPIAN SERIES

CHESTER GROUP

General relationships.—Wherever observed the upper formation of the Chester group was the Clore. On account of the erosional unconformity at the top of the Chester the thickness of the Clore necessarily varies from place to place. The whole formation may be absent in some localities, and the Pottsville rest directly upon the Palestine sandstone, the formation

which underlies the Clore. The succession of Chester formations and thickness are given on Plate IV. An erosional break exists between nearly every two adjacent Chester formations, but practically all these irregularities are comparatively small. In the Lawrence County oil field the Chester group contains the "Gas", Kirkwood, and Tracey sands.

Clore formation.—The Clore formation as exposed in the southern part of the area varies from 80 to 110 feet in thickness. It may be much thinner underneath the Pottsville to the north of the outcrop. The formation comprises limestone and shale members with thinner interbedded shaly limestone and shale. The shales are typically red and green in color.

Palestine formation.—The Palestine is essentially a sandstone formation. Typical exposures for the area may be seen about three miles east of Cobden. The formation here comprises an upper member of white, medium-grained, cliff-forming sandstone about 50 feet in thickness, and a lower member of thin-bedded, brownish sandstone interbedded with sandy shale, about 30 feet thick.

Menard formation.—The Menard formation is composed of limestone and shale beds. Much of the limestone is shaly, and the shale contains limestone lenses and some concretions. The limestone is dark colored and near the base contains considerable dark chert. The thickness is approximately 150 feet.

Tar Springs formation.—The Tar Springs formation is principally sandstone. In places sandy shales are interbedded with the thicker sandstones. The latter is much cross-bedded locally. The thickness is probably between 125 and 150 feet.

Sloans Valley formation.—The Sloans Valley formation is composed of interbedded limestones and shales. What is probably Sloans Valley, but is possibly Golconda, outcrops in the southern part of the area. The thickness seen was not over 50 feet and was chiefly limestone.

Hardinsburg formation.—The Hardinsburg formation is a moderately fine-grained, yellowish-brown sandstone. It was not recognized in the section in the southern part of the area. It may or may not be penetrated by the drill north of the Chester area.

Golconda formation.—The Golconda formation is principally limestone. Some shale which is variable in color and character is found. A red shale has been seen locally. What was tentatively thought to be Sloans Valley may be part of the Golconda formation. The thickness, however, is probably not much more than 50 feet.

Cypress formation.—The Cypress is chiefly a sandstone formation, although in the lower part is a sandy, greenish shale which may have a limestone bed in the middle. The sandstone is fine grained and yellowish brown in color. The upper sandstone forms cliffs in places. The thickness is between 100 and 150 feet.

Renault formation.—The Renault comprises interbedded limestones and shales. The limestone is quite variable in both character and composition.

Renault formation.—The Renault comprises interbedded limestones and shales. The limestone is quite variable in both character and composition. The shales are both clayey and sandy and green, blue, or purple in color. It contains some oolitic limestones and limestone conglomerate beds. The thickness is about 100 feet.

STE. GENEVIEVE LIMESTONE

The Ste. Genevieve formation is made up almost entirely of limestone, some of which is oolitic. Near the middle of the formation in the Lawrence County field an oolite bed produces large quantities of oil. It is in the position of the McClosky sand in Illinois. The thickness of the formation in this area is about 80 feet.

ST. LOUIS LIMESTONE

The St. Louis formation is composed of hard, dense limestone and considerable chert. The top of this formation should limit any drilling operations in the district.

OIL AND GAS

ACCUMULATION OF OIL

Oil as it is formed in the sediments is in so disseminated a condition that it has no economic value, but through the factors that cause circulation the oil gathers into pools of such size that commercial exploitation is made possible. To assure such circulation a porous stratum is essential; sandstones are the most favorable strata for this movement. Another important requirement is that the porous stratum must have an impervious cap rock. Without this condition all the lighter constituents of the petroleum would escape and leave only the heavier and less valuable materials.

Numerous geologic structures are favorable for the accumulation of oil and gas. In the area described in this report only a few of these type structures were found and therefore only these will be mentioned. They are the anticline, the dome, the terrace, and combinations of these types of structure.

After the geologic structure is known, the next factor to be determined is the degree of saturation of the rocks. Oil and gas will appear only as high in a structure as is the level of the water in the oil-bearing stratum or strata. If the oil sand is completely saturated the oil or gas, or both, will be found in the higher parts of the structure, the gas being above, the oil next, and water below. If the oil sand is dry, the accumulation will be in the lowest structure or syncline. If the oil sand is partly saturated the oil and gas will rise to an elevation in the structure dependent upon the height of the water and the amount of oil and gas trapped in the structure.

Diagrammatic cross-sections showing the effect of certain geologic structures on oil accumulation are given in figure 5 of the preceding paper in this bulletin.

It should be made clear that in addition to these general laws there are numerous factors which may arise that make each region, almost each locality, a special problem. Such things as irregularity in sedimentation during the deposition of the various sands whereby a given oil-bearing stratum may thin or pinch out entirely, differential cementation of parts of the oil sand, unconformities between, and in cases within, the various formations, and varying depths to the sands at different localities are conditions that can be determined only by a very careful study of a region and of each particular locality.

STRUCTURE

GENERAL STATEMENT

The general structure of the rocks in southern Illinois is a gentle dip north and northeast toward the center of the Illinois basin which lies in Wayne, Hamilton, White, and Edwards counties. The general dip is interrupted in many places by small irregularities which are the result of earth movements in past ages. The lines along which the more pronounced disturbances have taken place mark, in many cases, old shore-lines of previous geologic periods. This interpretation may aid us in accounting for the irregular character and thickness of the various beds penetrated with the drill in prospecting for oil. Many of the smaller irregularities have been formed as a result of the larger disturbances and, therefore, parallel them in many cases.

MAKANDA ANTICLINE

The Makanda anticline is shown on Plates V and VI. It extends from a point one-half mile west of Makanda, in the SW. $\frac{1}{4}$ sec. 28, T. 10 S., R. 1 W., in a general east-northeast direction to the NE. $\frac{1}{4}$ sec. 22, T. 10 S., R. 1 E., a point $1\frac{1}{4}$ miles southeast of Cottage Home. The length is about eight miles. The full lines marking the axis of the anticline show areas where outcrops made the location of the structure relatively accurate; the broken lines cover areas where practically all rock outcrops are hidden beneath drift and loess. However, the anticline is probably continuous. It is wholly within the Pottsville area.

Both limbs of the anticline dip gently, and the axis pitches to the northeast with the regional dip. The axis, however, apparently has high and low areas making a series of low, elongate domes.

The arch is so low and the sides dip so gently that the structure has had practically no effect upon the development of the topography. The west and east ends of the anticline are in rough country, the heavy sandstones having been deeply eroded. The sandstones of these two parts of the anticline are at different stratigraphic positions. The one at the east end is much higher in the Pottsville formation than the Makanda sand-



LEGEND

- County line
- Township line
- Railroad
- Town location
- Elevation

T.12 S.

Scale

1 2

of parts of Williamson

32

30

32

R.3.W.

R.4.W.



T.9.S.

T.10.S.

T.10.S.

stone. Between the rough areas near the two ends the country is hilly and rolling, the sandstone beds being relatively thin.

One of the high areas on the Makanda anticline is near the town of Makanda. As shown on the map, this area extends from the east side of section 28 to the northeast side of section 27, a distance of about one mile. The highest point is probably close to the north center of the SW. $\frac{1}{4}$, section 27 on the east side of the railroad. At this point the arch is probably about 60 feet in height, an amount which shows a very low anticlinal fold.

In the NE. $\frac{1}{4}$ section 27 the sandstone dips several degrees to the northeast. From this point to the NE. $\frac{1}{4}$ section 26 there is a low area on the anticline. On the map this is shown as a less favorable area. From the NE. $\frac{1}{4}$ sec. 26, T. 10 S., R. 1 W., to the north center sec. 19, T. 10 S., R. 1 E., the relations of high and low areas could not be determined. However, general conditions point to the existence of a slightly higher area over this distance.

From the north center of section 19 to the NW. $\frac{1}{4}$ section 21 the axis of the anticline is probably lower than to the east or west. The high area at the eastern end of the anticline extends from the NW. $\frac{1}{4}$ section 21 to the north center of section 22. The highest point is where Big Grassy Creek cuts across the anticline in the NE. $\frac{1}{4}$ section 21. East of this area the anticline dips to the east, and, owing to the topography, could not be traced farther.

The thickness of the Pottsville, or depth to the Chester beds, along the Makanda anticline is variable; the least distance to these beds would be at the western end, the greatest at the eastern end, a condition due entirely to the regional dip. In the stream valley near Makanda probably less than 100 feet of Pottsville would have to be penetrated before reaching the Chester limestone. On the surrounding hills the depth to the Chester would be greater according to the location chosen. In the stream valley which crosses the high area at the eastern end of the anticline close to 600 feet of the Pottsville formation would have to be penetrated before the Chester limestone would be reached. Between these two areas the thickness of the Pottsville would vary proportionately.

CEDAR CREEK DOME

The Cedar Creek dome occupies approximately the center of the square formed by lines drawn between the towns of Pomona and Etherton on the west, and Makanda and Boskydell on the east. The dome lies principally within secs. 11, 12, 13, 14, 23, 24, 25, and 26, T. 10 S., R. 2 W. (See Plates V and VI.)

The Cedar Creek dome is an irregular structure and is elongate in a north-south direction. The creek apparently has cut the dome along the

axis. The topography is very rough, sandstone cliffs rising above the creek on both sides to a height of over 100 feet. The creek bends west just a little south of the high point at the northern end of the dome. In pre-glacial time this bend of Cedar Creek was about one-fourth mile north of the present bend. The road which runs west to the south center of section 11 approximately follows the pre-glacial channel of the stream. The drift deposited by the glacier, which is thick in the central and northern half of section 12, dammed the stream and caused it to cut a new channel westward in the southwest corner of section 12. The branch which flows from the south through sections 14 and 13 has a fall of about 50 feet where it empties into Cedar Creek and the topographic expression along its course is in marked contrast to that of the older and larger stream. A shallow syncline is present in the northeastern corner of the dome extending from the NE. $\frac{1}{4}$ section 13 to the south center section 12. The high, cliff-surrounded ridge separating Cedar Creek proper and the eastern branch, which bends in through section 12, outlines the synclinal structure. It is clear that the courses of the pre-glacial parts of the stream system in the immediate area followed the high parts of the structure. A small shallow synclinal trough is also present on the west side of the dome in section 14.

Probably the maximum dip of any side of the dome is about 3 degrees, although locally there may be a few places where this figure is exceeded. The average dip of the steepest part of the structure will not exceed 2 degrees. The height of the dome, therefore, probably does not exceed 100 feet at any point, and in some parts it is much less than 100 feet.

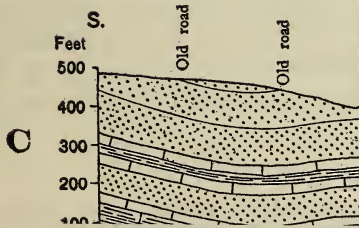
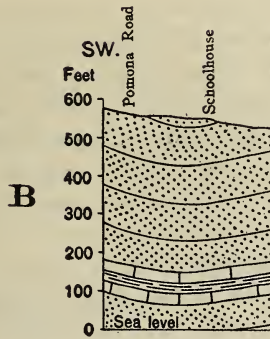
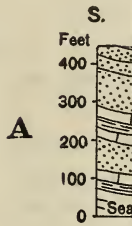
The shallow syncline in sections 12 and 13 is of such minor proportions that it would probably have but small influence upon the larger and general relations of the structure. The small syncline in section 14 should be avoided in the initial prospecting of the dome.

COBDEN TERRACE

The Cobden terrace, shown on Plates V and VI, is an irregular structure which lies about three miles east of Cobden. Only reconnaissance work was done on the area, no levels having been run on any horizon, and, therefore, the writer wishes only to call attention to the area as a possible structure which may possess some attractive features.

At least a partially developed terrace lies within the escarpment hills the western boundary of which is the ridge running northeast through secs. 29, 20, 19, and 18, T. 11 S., R. 1 E. The southern boundary follows approximately the county road from the SW. corner sec. 27, T. 11 S., R. 1 W., to Pleasant Hill School, west center sec. 29, T. 11 S., R. 1 E. The northern boundary is about at the divide in the north center sec. 13, T. 11 S., R. 1 W. Part of the evidence used in determining this struc-

ILLINOIS STATE GEOLOGICAL SURVEY



ture is based upon the approximate elevations on the Pottsville-Chester contact which is an unconformable one. However, throughout the region the thickness of the upper formation of the Chester, the Clore, did not show a variation of over 30 feet, a characteristic that shows that the unconformity, at least for this area, is not very pronounced.

The most pronounced dips are shown in the Palestine formation in secs. 27 and SW. $\frac{1}{4}$ sec. 23, where the sandstone forms an escarpment. Dips as high as 8 degrees are displayed in places, although the average is close to 3 degrees. The prevailing direction of dip is west and a little north of west.

To the north of the terrace the strata dip gently to the north and east of north; on the east, the beds dip gently to the east and northeast.

Attention is called to the following minor irregularities more for their physical features than for their possible value as oil structures. Should the sand formations underlying the more pronounced structures of the region prove to be oil bearing, further and more detailed consideration should then be given to the minor structures.

In T. 11 S., R. 1 E., is a very small fold which starts approximately at the center of section 14, curves slightly northwest, then west to the center of section 15, and then curves northwest to the SE. $\frac{1}{4}$ section 9.

In the south center of sec. 4, east half sec. 8, and NW. half sec. 9, T. 11 S., R. 1 W., is a low, partial doming of the rocks. To the south and east the structure is indefinite.

A somewhat similar, irregularly shaped, low, partial doming is to be seen in the south half of sec. 33, T. 10 S., R. 1 W.

In T. 9 S., R. 2 W., a small terrace extends from the center of section 16 west to the center of section 17, thence northwest to the section line.

FAULTS

The faults which were found in this area are too far removed from the structures described to have any effect upon the possible accumulation of oil in these particular structures. The usual effect of faulting is to lessen the probability of oil accumulation. Where the strata have been broken there are avenues of escape for the hydrocarbons. However, in some localities faulting has produced the opposite effect. The fault planes may be sealed by the shearing and by the metamorphism resulting from the movement thereby causing a ponding of the oil on the down-dip side of the fault.

No faulting was found which might affect accumulation in either the Makanda anticline or the Cedar Creek dome. A small fault is thought to be present at the extreme southwest corner of the Cobden terrace. Its influence, however, is considered negligible.

The large fault in the southwestern part of the area is of regional importance. Its location on the map is only approximate, the intention

being simply to show the general relations of the structure. The rocks on the south side of the fault belong to very much older formations than those on the north side. In the former are represented Devonian and lower Mississippian; in the latter Chester and Pennsylvanian.

The smaller faults which were encountered in the reconnaissance of the area are recorded on the map, but no effort was made to trace them for any distance. Their displacements are thought to be small in all cases.

UNCONFORMITIES AND THEIR SIGNIFICANCE

Unconformities exist between most of the formations found in this area. However, the only important one is recorded between the Chester group and the Pottsville formation of the Pennsylvanian series. No great



FIG. 11.—Unconformity between the Chester and Pottsville formations two miles south of Pomona.

amount of erosion and probably no folding took place at the breaks recorded between the various Chester formations. Therefore these formations should be uniformly regular in their thicknesses and the strata of each formation practically parallel with the underlying or overlying strata.

The break between the Chester and Pottsville was marked by both erosion and folding. The amount of erosion has been considerable in many places. In the area described in this report the erosion of the upper Chester formation, the Clore, was relatively slight, a variation in thickness of only 30 or 40 feet being recorded. This estimate has been gathered both from outcrops of the Clore and from the few drill records available in the area.

Striking discordances of dip were found in only two places in the area described in this report. Near the center of sec. 33, T. 10 S., R. 2 W., along the Mobile and Ohio tracks, a small fault, producing steeply dipping beds is recorded in the Clore formation. Overlying the Clore the basal beds of the Pottsville are undisturbed (fig. 11). The second discordance is shown in the dips of the Palestine and Pottsville sandstones at the southwest corner of the Cobden terrace, in the NE. $\frac{1}{4}$ sec. 27, T. 11 S., R. 1 W. Both sandstones form escarpments which are close together. The Palestine has a dip of 8 to 9 degrees westward and the overlying Pottsville has a dip of only 3 degrees.

The existence of this structural discordance between Chester and Pottsville is emphasized so that caution should be exercised in drilling low structures which are recorded in the Pennsylvanian rocks. Although only minor differences in the attitude or lay of the rocks of the two series have been shown to exist where geological data are available, there is the possibility of such irregularities being present and offsetting the value of later folding in the higher rocks. In pronounced structures such as are found in Johnson and Pope counties the slight structure of the Chester may be considered negligible, but in low structures such as are described in this report, the influence which may be exerted by pre-Pennsylvanian structure should be given due consideration.

RECOMMENDATIONS FOR DRILLING

The Survey does not pretend to predict the presence of commercial oil and gas in this region. Furthermore, the structure is extremely mild as compared with that farther east in Williamson and Saline counties.

If oil should be developed in either the New Burnside or the McCormick anticlines, described in the second part of this bulletin, the structures mentioned herein, would be worthy of conservative exploration.

The beds to be penetrated in this area are part of the Pottsville formation and the Chester formations. The lower limit should be the oolitic beds of the Ste. Genevieve.

On the Makanda anticline near the west end, should drilling be done in the stream valley which crosses the anticline, probably not more than 100 feet of Pottsville would be encountered. The approximate depths of the Chester horizons below this are shown on the graphic section (Plate IV). At any point on the surrounding hills the depths would be increased according to increase of the topographic elevation. East of Makanda on the anticline the thickness of the Pottsville which must be penetrated by the drill increases proportionately until at the eastern end the depth to the Chester limestone is about 600 feet.

On the Cedar Creek dome drilling in the stream valley would encounter probably not more than 100 feet of Pottsville. On the higher elevations the depths would be proportionately greater.

On the Cobden terrace the minimum depth of drilling in the entire area would penetrate all the possible Chester oil horizons. Depths of from 700 to 950 feet, according to the location chosen, would reach the oolitic Ste. Genevieve beds.

The Chester formations probably vary in thickness and character in different parts of the area. The graphic section (Pl. IV) is given merely as a guide. Although the Hardinsburg sandstone and the Golconda limestone were not recognized in the southern part of the area where they should outcrop, they may be encountered by the drill farther north. Their thicknesses, however, should not be very great.

Any sandstone that is continuous in its distribution toward the region from where the oil is supposed to have migrated—in this case the central Illinois basin—and that is not too closely cemented, can be regarded as a possible oil horizon. The Chester formations thin northward, some pinching out probably before the central Illinois basin, which lies approximately in the vicinity of southern Wayne County, is reached. Since it is impossible to determine which one of the Chester sandstones may be thus affected, all the sandstone horizons which underlie the area described herein may, for the present, be regarded as possible oil sands. There are four producing Chester sands in the Lawrence-Crawford County oil field and as many may be present in this region. Where the Pottsville has sufficient thickness, oil may also be found at favorable positions within the formation.

Since the structures described are low and the dips small, test wells should be located with great care. The highest parts of the Makanda anticline should be tested first. If this be done and the rocks found to be dry, or to contain a little gas, the drill should be moved a little lower down the dip of the limbs or pitch of the anticline until either oil or salt water is encountered in the various sand horizons.

On the Cedar Creek dome the highest part should be the first chosen. This is approximately along the course of Cedar Creek except in a small area in the SW. $\frac{1}{4}$ section 12, where the course of the pre-glacial stream probably follows the higher part. Similar methods to those described above should be used to locate the upper and lower limits of the possible oil pool.

On the Cobden terrace, because of its irregularities, more detailed work should be done before a location is selected for a test well.

LOCALITIES ALREADY TESTED

A drill hole was put down near the center of section 16, T. 10 S., R. 1 W., $2\frac{1}{2}$ miles north of Makanda, to a depth of 390 feet. The for-

mations penetrated were the Pottsville, composed of sandstone and sandy shale to a depth of 305 feet, and the Clore limestone, the drilling having been discontinued after going 85 feet into this formation.

A test well for oil was drilled in the extreme NE. cor. sec. 16, T. 11 S., R. 1 W., about 3 miles northeast of Cobden, to a depth of 1,240 feet. The location was practically at the base of the Pottsville, so the beds penetrated were Chester and lower. From the log of the well it is probable that the drill passed through the St. Louis cherty formation and stopped in the Salem limestone. The expected succession of Chester was encountered, several sand horizons having been present. According to the record salt water was struck at 970 feet and probably came from the Ste. Genevieve. Salt water was also encountered at 1,240 feet, the bottom of the hole. At the present time an excellent flow of fresh water comes from the drive pipe. The hole was, unfortunately, located in a pronounced syncline. The test is, therefore, of no value whatever and should not discourage well-directed efforts where favorable structure exists.

A drill hole north of Carbondale is of value only in showing the thicknesses of the formations penetrated. The Carbondale formation was 257 feet thick, the Pottsville 676 feet, the Clore 79 feet, and the Palestine about 70 feet. The hole, which was 1,379 feet in depth ended in the Menard formation, having passed through about 146 feet of it.

OIL POSSIBILITIES OF AVA AREA

By Stuart St. Clair

OUTLINE

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INTRODUCTION

AREA TREATED IN REPORT

The area covered by this report lies in the extreme northwestern corner of Jackson County. The principal town is Ava which is on the Mobile and Ohio Railroad. Campbell Hill, four miles to the northwest of Ava, is also located on the same railroad.

CHARACTER AND OBJECT OF INVESTIGATIONS

The area was very superficially examined by the writer during the early part of August, 1916. Several days were spent in the vicinity of Ava, but only two days were actually put upon the structure described in this report. The work was prompted by numerous requests from residents of the district and also by the discovery of some oil and gas.

The Sugar Hill dome shown on Plate VII was mapped by E. W. Shaw of the United States Geological Survey in cooperation with the State Geological Survey. The result of that work appeared in the folio report on the Murphysboro quadrangle. The object of the writer's work was to determine whether or not the structure continued westward, and approximately how far.

One producing gas well is in the south center of sec. 11, T. 7 S., R. 4 W., on the Froemling farm. The well has been capped, and the gas is used for domestic purposes by the owner of the property. Records of other wells are given under a subsequent heading.

TOPOGRAPHY

The topography of the area is somewhat varied. Where the heavy sandstones of the Pottsville outcrop, the surface is hilly and rough. In the western part, the Chester limestones have had a modifying influence, the erosion of the surface having produced more rounded hills and gentle slopes. The northern part is underlain by the soft shales of the Carbondale formation, and the surface is gently rolling. Glacial drift and loess have modified the characteristic surface features in many places.

STRATIGRAPHY

GENERAL RELATIONSHIPS

The rocks which outcrop in the area belong to three formations only, the Carbondale and Pottsville of the Pennsylvanian series, and the upper Chester limestone, probably the Clore formation, of the Mississippian series. Other formations of the Chester underlie the area and are encountered in drilling. All the possible oil sands probably lie within the Chester group.

CARBONDALE FORMATION

The Carbondale formation is composed chiefly of shale, with some sandstone and limestone. The base is the bottom of coal No. 2 or Murphysboro coal. Locally the Vergennes sandstone member is prominently developed and is in the lower part of the formation. In the upper part are the horizons of coals No. 5 and No. 6, the top of the latter marking the top of the formation. The limestone beds occur principally in the upper part, there being a good exposure a little north of Campbell Hill village. The Carbondale is found only in the eastern part of the area, in the vicinity of Sato and in the hills to the west; in the hills in the neighborhood of Ava; and north of the fault which apparently parallels the anticline for at least part of its length.

POTTSVILLE FORMATION

The Pottsville formation is composed chiefly of sandstone and sandy shale. The top is defined by the base of coal No. 2 and the base by the

Chester limestone. The Pottsville lies unconformably upon the Chester, and its thickness, therefore, is variable. Drill holes and additional computations show an average of about 400 feet in the Campbell Hill area. However, the log of one drill hole which started practically at the top of the Pottsville showed a thickness of 460 feet of sand and shale to the first limestone. The Pottsville formation outcrops over the greater part of the area described and is the surface rock on the anticline.

CHESTER GROUP

The Chester is made up of a group of formations which comprise limestones, shales, sandstones, and sandy, cherty, and shaly limestones. Some of the limestones are oolitic and may contain oil and gas. The Chester sandstones are, however, the beds in which oil and gas are more likely to be found.

On account of the unconformity at the top of the Chester, and also minor irregularities, as well as variable formational thicknesses, the total thickness of the Chester group may vary considerably in short distances. From measurements made in Randolph County by Professor Weller, the maximum thickness is about 635 feet. If drill records in the vicinity of Ava have been correctly recorded, the Chester attains a thickness of at least 1,000 feet for this district. The Chester limestone outcrops only in the western part of the area shown on Plate VII.

STE. GENEVIEVE AND ST. LOUIS FORMATIONS

Underlying the Chester are the Ste. Genevieve and St. Louis limestones. The former, if it contains its characteristic oolitic beds, may be an important oil formation. The St. Louis, which is a hard, cherty limestone, should mark the lower limit of prospecting in this area.

OIL AND GAS

ACCUMULATION OF OIL AND GAS

In regions where certain rock formations are petroliferous, the contained oil and gas move through various agencies along porous strata and become trapped and form pools where structural conditions are favorable. The anticline and dome are recognized structures where, other conditions being favorable, oil and gas accumulate. Sealed faults have also acted as barriers to the movement of oil and gas, and have caused ponding on the down-dip side.

The effect of the fault on the north side of the structure can not be foretold. If the movement and shearing effect have sealed the fault plane, any oil or gas moving up the dip of the strata from the north and north-east would become impounded and would, therefore, not reach the anticline

from that side. All oil and gas that collected in the anticline would have to come from the east and southeast sides.

If the fault plane has not been sealed by the movement of the rocks, then all the oil and gas coming from the area to the north and northeast has either seeped out through the fault plane and been lost, or part or all the oil and gas have moved upward along the fault plane until other porous strata have been encountered and then traveled onward up the dipping beds and subsequently collected in the anticlines, providing the reservoir has an impervious cover and the water stands sufficiently high in the oil-bearing strata. (See figure 5 of the second paper in this bulletin.) Both oil and gas have been found on the anticline so there has been some accumulation, but from which direction it is impossible to state.

STRUCTURE

GENERAL RELATIONSHIPS

The Campbell Hill anticline is probably a southwestern extension of the Duquoin anticline, a structure that has been traced from the Sandoval oil field south through Centralia to Duquoin. The geologic map of the Murphysboro quadrangle shows a northeastward-plunging anticline which continues southeast and west to the Sugar Hill area. The same structure continues westward and joins what is described as the Campbell Hill anticline in this report.

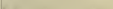
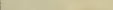
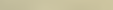
The fault shown on Plate VII is taken from the Murphysboro geologic map. The vertical displacement was reported to be between 100 and 200 feet. The fault evidently bends with the anticline in its westward extension and probably passes close to the village of Campbell Hill, for a coal bed with accompanying limestone, which was thought to be coal No. 5 in the upper part of the Carbondale formation, outcrops just north of the village. The fault appears to conform with the basic structure of the region and, therefore, probably dies out to the southwest.

SUGAR HILL DOME

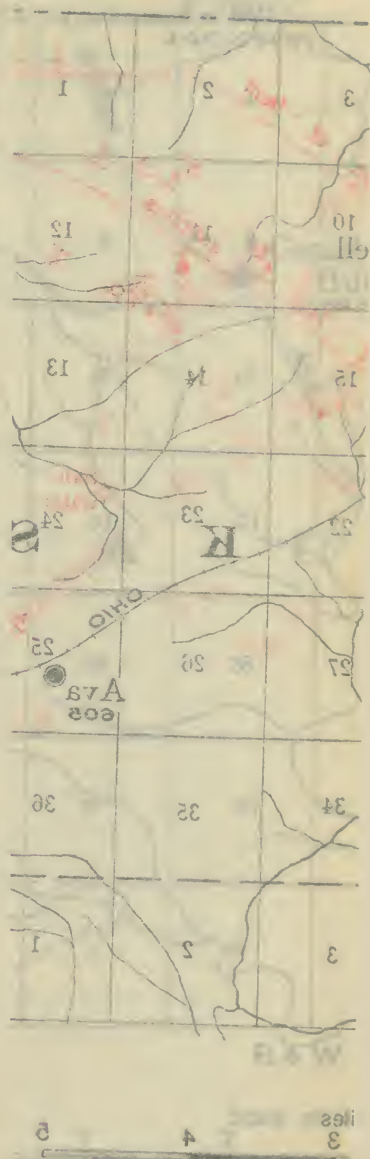
Sugar Hill dome has already been shown on the geologic map of the Murphysboro quadrangle. It lies in parts of secs. 4, 5, 8, and 9, T. 7 S., R. 3 W. To the east the anticlinal structure pitches steeply; to the west there is a low saddle which connects the dome with the Campbell Hill anticline.

The writer made no further study of the Sugar Hill dome. Structure contours drawn by E. W. Shaw show the rock strata on the top of the dome to be stratigraphically from 25 to 75 feet below the top of the Pottsville formation. In a well drilled to a depth of 1,315 feet near the top of the dome in section 9, one salt sand 65 feet thick was reported at a depth of 665. The log of this well can not be correlated with the logs of the

LEGEND

-  County line
-  Township line
-  Railroad
-  Town location
- 545** Elevation at town
-  Abandoned oil well
-  Gas well
-  Show of gas
-  Dry hole

The arrows and accompanying figures show the direction and amount of dip.



R.4.W.

PERRY

JACKSON

MOBILE

9 Camp
Hill

10

31

38

33

4

R.4.W.

6

1

7

18

10

30

31

6

13

13

34

32

36

1

T.7.S.

33

36

32

3

JACKSON
RANDOLPH

34

32

Deogonia

2

R.5.W.

Scale of m
0 1 2

Map showing geologic structure

wells three miles to the west which record oil and gas at several horizons. Several conditions may exist, any one of which might explain the failure of the well located on the dome and the apparent discordance in the well records. The Sugar Hill well may be too high on the dome to have tapped the oil pool which would rest upon the surface of the salt water in the various oil formations. One salt water sand should not condemn further well-directed attempts to prospect other possible oil sands. Again, the possible oil sands may be lenticular, and those encountered in one well may not appear in other wells within a reasonable radius; or there may be some structural condition unknown at the present time which affects the dome and not the anticline to the west.

The writer is unable to make further comment upon the Sugar Hill dome, for, combined with a lack of detailed field facts, the paucity of drill records for the district forbids theoretical deductions regarding the character of the Chester sands and the possible height of any oil in the structure.

CAMPBELL HILL ANTICLINE

The Campbell Hill anticline extends from Fork Creek, SE. cor. sec. 6, T. 7 S., R. 3 W., westward to the southwest corner of the section, thence southwestward to sec. 30, T. 7 S., R. 4 W., where the structure begins to flatten perceptibly. The total length is between seven and eight miles. The general structure of the anticline is a gentle pitch to the northeast, conforming thereby with the regional dip of the strata, and gently dipping limbs, the northern limb having the steeper dip. Low, elongate doming on the anticline is strongly suggested by the topography and a little less so by the dip of the strata. However, the surficial covering of drift and loess prevented observations on rock strata on top of the anticline. The saddle between the Campbell Hill anticline and the Sugar Hill dome is clearly shown on the Murphysboro geologic map. The saddle near the southwestern end of the anticline which would mark the western extension of the elongate dome area is probably in the vicinity of the NW. cor. sec. 29, T. 7 S., R. 4 W. From the east side of sec. 30, T. 7 S., R. 4 W., the anticline gradually flattens to the southwest. The reconnaissance was not carried beyond the southwest corner of section 30.

The oldest rocks exposed on the anticline as far as mapped are Pottsville in age. In sec. 11, T. 7 S., R. 4 W., the surface is between 30 and 50 feet from the top of the formation; in section 20, between 100 and 150 feet; and in section 30, where the dips are flattening, probably close to 200 feet from the top. This relation shows in general a slight pitch to the axis of the anticline.

Both oil and gas have been struck on the Campbell Hill anticline, and one gas well is producing at the present time. Drill records show oil in two holes. Probably the greatest width of the anticline is about two miles.

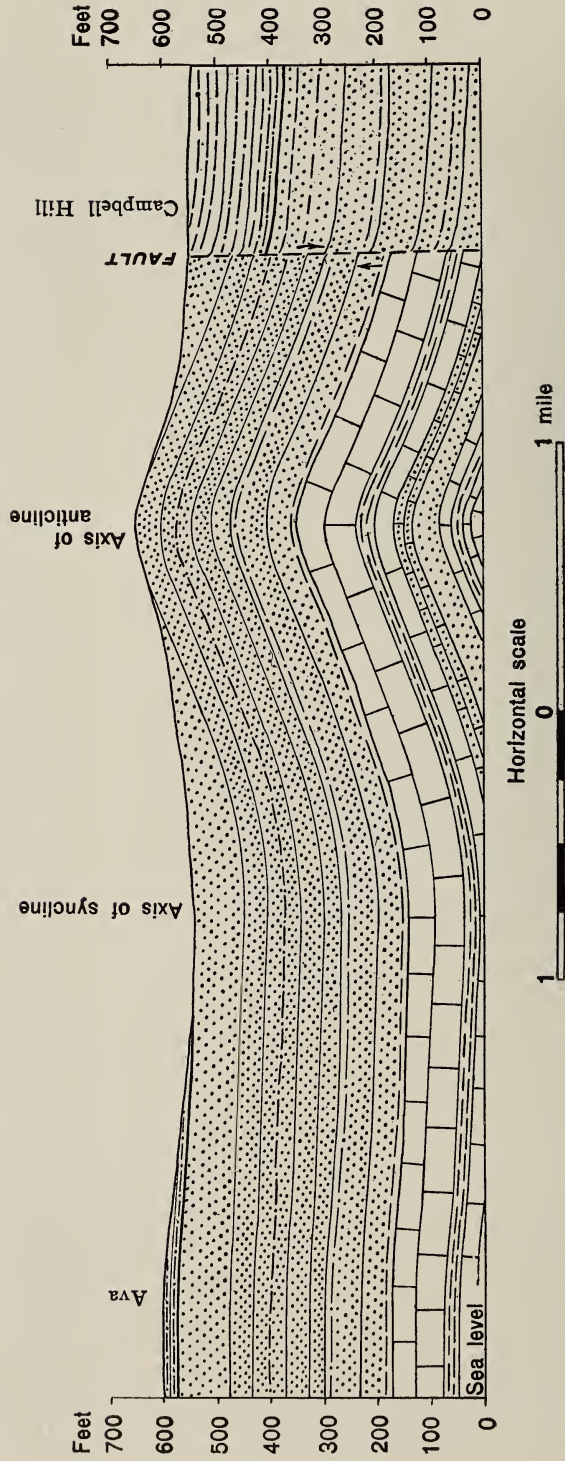


Fig. 12.—Cross-section of Campbell Hill anticline.

The south side has the gentler dip, the average being about 2 degrees. The average dip of the north limb is probably close to 3 degrees. A cross-section of the anticline is shown in figure 12.

RECORD OF DRILLING

A number of wells have been drilled in the area, the locations of some having been well chosen for an oil test. The three Froemling wells, located in the SE. $\frac{1}{4}$ sec. 11, T. 7 S., R. 4 W., are close to the top of the Campbell Hill anticline. The results of these tests were encouraging according to reports given the writer. In the first well, at a depth of a little less than 600 feet, both oil and gas were struck. Drilling was continued and another oil show was encountered at a little more than 800 feet. The hole was plugged after being drilled to a depth of 1,173 feet. The other two Froemling wells went only to the sand which is about 600 feet deep. Gas was struck in both. One of the holes was plugged, but the other was capped and the gas piped to the house of the owner of the farm. A well completed January, 1917, in the east-central part of section 11 and 300 feet from the Froemling wells, found only a light showing of oil and gas in the top of the sand at 551 feet, below which salt water filled the sand to 601 feet where drilling was stopped.

Another well on the same structure was drilled in the SW. $\frac{1}{4}$ sec. 12, T. 7 S., R. 4 W. This location is about one-fourth mile from the axis of the anticline on the south limb. The log of the well shows that the Chester limestone was struck about 100 feet lower than the elevation of this bed in the Froemling wells. A dry sand, which is said to have had an oil smell, was penetrated between 600 to 620 feet, or from 140 to 160 feet below the top of the Chester limestone. The hole was abandoned at a depth of 660 feet. If the log is correct the gas-sand horizon of the Froemling wells was not reached. This well should not be considered a negative test.

The Vogt well, in the NW. $\frac{1}{4}$ sec. 22, T. 7 S., R. 4 W., is on the south limb of the anticline and about half a mile from the axis. The depth is 926 feet, and it is reported that considerable oil was bailed from the well. The oil sand in this well is probably the same as the Froemling 600-foot sand.

A well was drilled to a depth of 1,315 feet in the NW. $\frac{1}{4}$ sec. 9, T. 7 S., R. 3 W., and near the top of the Sugar Hill dome. The log of this well differs materially from the log of the deep Froemling well. No oil or gas was reported, although a number of sands were encountered. Only one salt sand is recorded, and it was 65 feet thick, from 665 to 730 feet in depth.

Unsuccessful tests were made in the NW. $\frac{1}{4}$ sec. 18, T. 7 S., R. 3 W., and in the NW. $\frac{1}{4}$ sec. 24, T. 7 S., R. 4 W. Both locations, however, were in a syncline.

A well in which a little oil and gas were said to have been struck was drilled about half a mile south of Ava. Reference to the geologic map of the Murphysboro quadrangle shows a small terrace structure at this point which develops into an anticlinal saddle a little farther to the northeast.

South of the area described in this report a 1,250-foot well was put down in the SE. $\frac{1}{4}$ sec. 19, T. 8 S., R. 3 W. Several sands were struck, but no oil or gas was present.

RECOMMENDATIONS FOR DRILLING

The sands underlying the Campbell Hill area which may be oil bearing are in the Chester group or the Ste. Genevieve formation. The sandstones and sandy limestone are irregular in thickness and character, and their depths below the base of the Pottsville may vary from place to place. The records of the three Froemling wells show that there is an oil and gas sand at a depth of about 200 feet below the base of the Pottsville. Probably the same sand horizon is said to have yielded oil in the Vogt well. Another sand which had an oil showing was about 440 feet below the base of the Pottsville in Froemling No. 1 well. Other wells in the vicinity passed through several sand horizons which under favorable structural conditions could be an oil reservoir.

On account of the probable variability in thicknesses of the Chester formations, one should hesitate to state the maximum depth to which drilling should be carried in order to prospect the area thoroughly. However, the Ste. Genevieve oolitic beds would probably be reached at a depth of 1,000 or 1,100 feet below the base of the Pottsville. The Ste. Genevieve underlies the interbedded sandstones, shales, and limestones of the Chester.

On account of the thinness of the Pottsville rocks in the area there is very little chance of obtaining oil from the basal beds which produce in other parts of the State.

In an untested area the higher parts of anticlines and domes should be tested first. Should the sands passed through be dry or gas bearing the next hole should be on the limb of the structure and on the one having the more gentle dip.

The higher part of the Campbell Hill anticline has been tested by the Froemling wells, and gas-bearing and oil-showing sands have been encountered. Therefore, further prospecting should be done farther down the dip and preferably on the southeast limb of the structure. If the reports concerning the showing of oil in the Vogt well be correct, the chances of striking oil for some distance down the dip from the axis are favorable as far as can be judged from the present meager data on the area.

The well on Sugar Hill dome should not be regarded a final test. Any other holes put down should be located a little farther down the dip of the structure.

The anticlinal saddle and terrace which extends southwest from Sugar Hill to a point half a mile south of Ava, is shown on Plate VII. It is taken from the Murphysboro geologic map. Drilling should *not* be done on this structure until oil has been definitely shown to exist in the rocks of the Campbell Hill anticline and at as low a structural elevation as the Ava saddle.

OIL POSSIBILITIES OF CENTRALIA AREA

By Stuart St. Clair

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INTRODUCTION

AREA TREATED IN REPORT

The area treated in this report lies in the southwest corner of Marion County and southeast corner of Clinton County. The principal city is Centralia, although both Carlyle and Sandoval are important towns since both are oil-producing centers. With the Sandoval oil field in the northern part of the area and the Carlyle field¹ just to the west, and more or less activity northeast and east of Centralia, the latent possibilities of the district are of interest to the oil man.

CHARACTER OF THE WORK

Since the area is drift covered, outcrops of the rock formations are few. As a result, the field work for this report consisted largely in securing logs, locations, and approximate surface elevations of the drill holes.

¹Shaw, E. W., The Carlyle oil field and the surrounding territory: Ill. State Geol. Survey Bull. 20, p. 43, 1916.

The accuracy of the resulting work is dependent largely upon two factors, the accuracy of the well logs and the number and location of drill holes. In general the correctness of the well logs must be accepted, unless there is an obvious inaccuracy, and the structure is drawn to a large extent upon such data. The paucity of drill holes in the Clinton County part of this area allows considerable chance for errors of interpretation of the structural conditions. Without doubt further drilling will supply facts which will probably necessitate small changes in the positions of the structure contours shown on Plate VIII.

Topographic maps of the Centralia and Carlyle quadrangles, which are published by the United States Geological Survey and the Illinois State Geological Survey in cooperation, were used in the field work.

STRATIGRAPHY

The surficial deposit of the area covered by this report is glacial drift, the thickness of which varies from place to place, the maximum thickness as far as known being about 150 feet. Along the streams, which have cut deeply into the drift, ledges of the youngest rock formation are exposed. All such outcrops are shale, sandstone, and limestone beds which belong to the McLeansboro formation. The thickness of the McLeansboro which will be encountered varies with the location and the topographic elevation. Since the structure contours are based on the top of coal No. 6, which horizon would correspond to the bottom of the McLeansboro, the thickness may be easily computed.

Underlying the McLeansboro is the Carbondale formation which is quite similar to the former in its makeup. The top of the Carbondale is marked by the top of coal No. 6. In many parts of the State the base of the formation is marked by coal No. 2, but in the Centralia area logs of drill holes rarely record this bed. The shallow sands of the Junction City area occur in the upper part of the Carbondale.

The Pottsville formation which is composed of heavy and thin sandstone beds as well as shales, underlies the Carbondale. In this area the Pottsville is usually reported as the salt-sand horizon.

Underlying the Pottsville are the interbedded limestone, sandstone, and shale formations of the Chester group. The productive Stein and Benoist sands of the Sandoval field, the Carlyle sand of the Carlyle field, and the deep sands in the producing wells east of Centralia are in the Chester.

OIL AND GAS

ACCUMULATION OF OIL AND GAS

Under favorable conditions of sand porosity and water saturation the tendency of oil and gas to accumulate in anticlines and domes, and on structural terraces has been shown in the development of the majority of

oil and gas fields. With this fact in mind, the finding of such structures is a justifiable signal for the oil man to start to prospect that particular area. In the Centralia area where oil is being produced in three districts, geologic study has shown that the oil pools are related to definite structural features.

The possibility of oil accumulation on the down-dip side of a sealed fault should also be mentioned. There is some evidence that such a condition exists in the area east of Centralia. General conditions are diagrammatically presented in figure 5 of the second paper in this bulletin.

STRUCTURE AND RECOMMENDATIONS

USE OF STRUCTURE CONTOURS

The structure of the area on Plate VIII is expressed by structure contours showing the approximate elevation of coal No. 6 above sea level. The practical use of the structure contours will be obvious with but a word of explanation. The approximate depth of coal No. 6 is the difference between the surface elevation, which can be determined from the topographic map of the area, and the structure contour elevation where the latter is above sea level, or the sum of the elevation of the surface and the structure contour elevation when the latter is minus or below sea level. Where the interval between the possible oil sands and coal No. 6 is known, the depth necessary to drill can easily be computed by simple addition.

FAULTS

The faults are, to some degree, theoretical, their positions and extents being assumed to explain discordances in drill records. In the Marion Coal Company's mine, NE. $\frac{1}{4}$ sec. 31, T. 2 N., R. 1 E., the northeast-southwest fault, the position of which is shown approximately on Plate VIII, has a displacement of about 30 feet with the downthrow to the northwest. The fault east of the abandoned shafts of the Centralia Coal Company, sec. 7, T. 1 N., R. 1 E., has a downthrow on the west side of about 110 feet. This fault probably connects with the smaller fault to the north. The southward extension of the fault can not be traced, but its approximate position may be determined from the relations shown by drill records.

It was necessary to assume the fault from sec. 6 to sec. 36, T. 1 N., R. 1 E., in order to show relations which the drill had recorded; its position is therefore only approximate. The downthrow is on the northeast side. Where similar contours connect, the fault dies out, and is replaced by a plunging anticline.

The Junction City dome is partly surrounded by faults. The small northeast-southwest fault has had some effect upon the accumulated oil in the dome, for oil has been seeping into the mine of the Marion Coal Company for a number of years.

AREA EAST OF CENTRALIA

One producing section lies east of Centralia. The Brown well, which is in the north center of sec. 16, T. 1 N., R. 1 E., has been pumping for a number of years. The oil sand is at a depth of about 1,650 feet, although there are several salt water sands above. Several other wells in the vicinity are said to have struck oil at the top of the sand, but the underlying salt water could not be controlled and flooded the wells.

The only structural feature that could account for the accumulation of oil in this section is the fault which is thought to lie just west of the Brown well. If the fault plane should be sealed at this point, there would be a small accumulation on the east side. If this sealed condition is present in other sections along the fault, other small producing pools may be struck. However, prospecting upon such assumptions can not be commended from a geologic point of view.

A condition probably similar to the Brown occurrence exists near the fault in the NW. cor. sec. 20, T. 1 N., R. 1 E., where a showing of oil was claimed in the well of the Miller Oil Company.

AREA EAST OF CENTRAL CITY

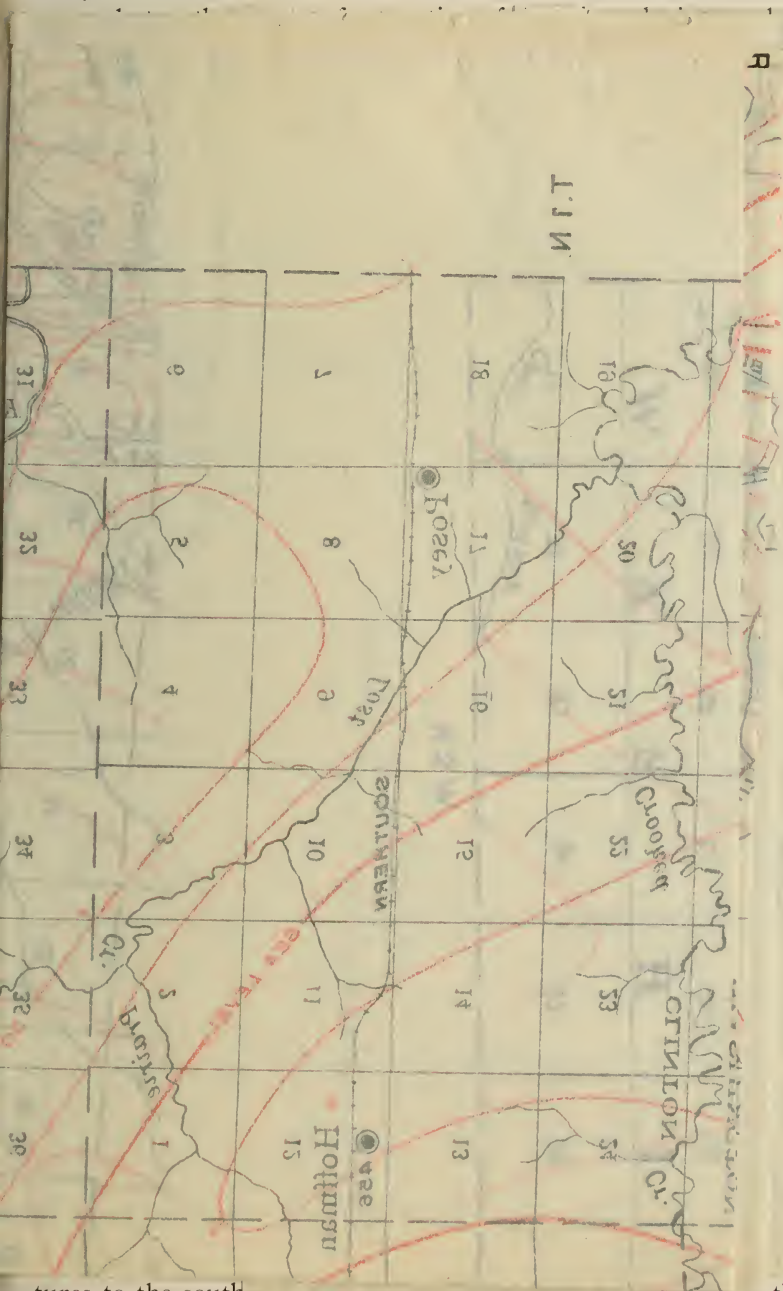
The producing section in the area east of Central City is in the west center of sec. 3, T. 1 N., R. 1 E. The two Kuester wells are pumping from a deep sand. Other wells in the vicinity are said to have had a showing of oil but were flooded by salt water. These wells are located on a plunging anticline where there is probably a slight terrace structure. Further drilling to the northwest for a distance not exceeding a half to three-quarters of a mile may extend this pool. However, only very small producing wells should be anticipated and the basis of risk should be calculated upon such returns. Great care should be taken not to drill too far into the oil sand, or the well will be flooded by the salt water which lies just below the thin stratum of oil.

JUNCTION CITY DOME

The Junction City dome is outlined by 10-foot contours on Plate VIII. Only a small area on the south flank of the dome has proved to be productive up to the present time. This area is outlined on the map, and in it are 10 pumping wells. The oil production is from shallow sands. The dip of the beds is much less on the south than on the north side. The small northeast-southwest fault is probably largely responsible for this relatively steep dip on the north side.

The upper or Dykstra sand is from 5 to 20 feet below coal No. 6 and has an average thickness of less than 10 feet. In some wells the Dykstra sand is apparently absent, a fact which shows its lenticular character. A show of oil is reported in most wells where this sand is present. The

Sherman well, in the southern part of sec. 29, T. 2 N., R. 1 E., went only to the Dykstra sand and resulted in the usual oil show. The well is apparently on the top of the dome and should have gone deeper in order to

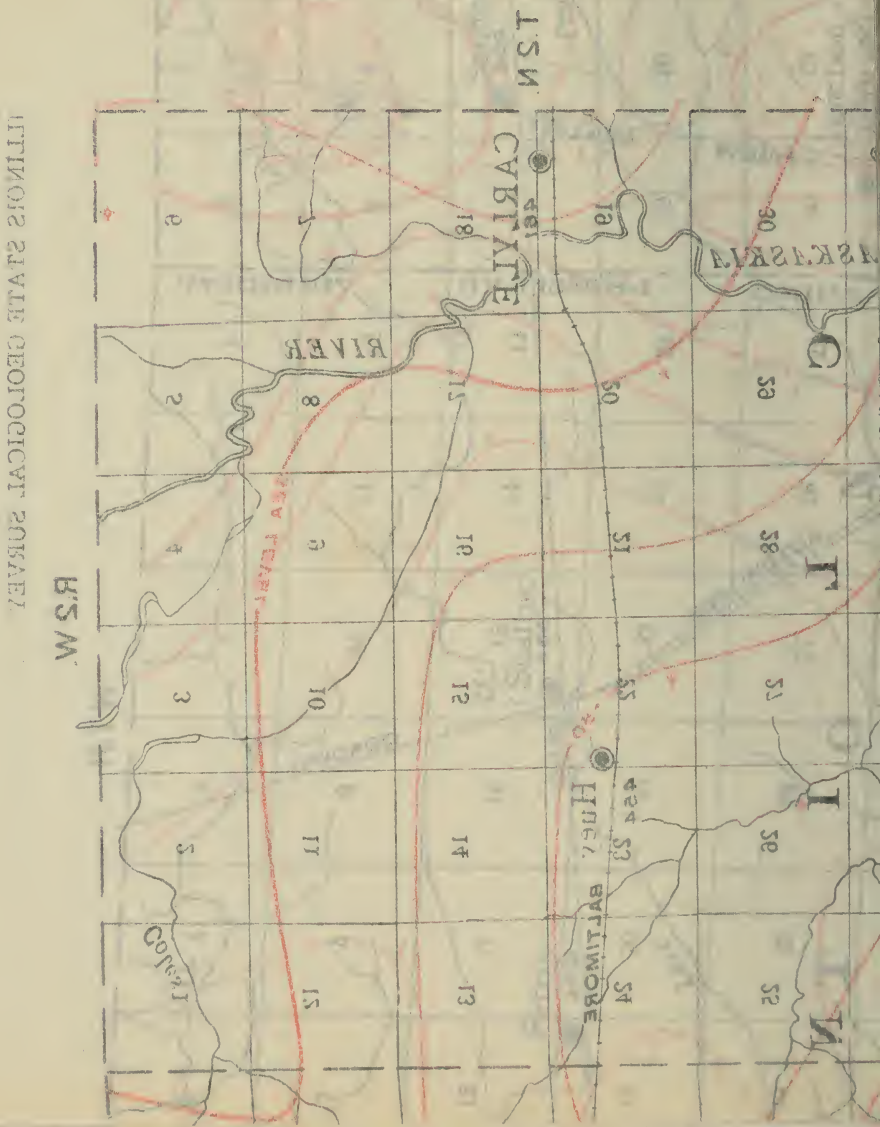


BULLETIN NO. 35, PLATE VIII

tures to the south, most want to give additional information on the producing

AREA EAST OF CENTRALIA

One producing section lies east of Centralia. The Brown well, which is in the north center of sec. 16, T. 1 N., R. 1 E., has been pumping for a number of years. The oil sand is at a depth of about 1,650 feet, although



Sherman well, in the southern part of sec. 29, T. 2 N., R. 1 E., went only to the Dykstra sand and resulted in the usual oil show. The well is apparently on the top of the dome and should have gone deeper in order to properly test the degree of saturation of the oil-producing sands in the dome.

The main oil sand of the dome is the Wilson sand which is between 100 and 110 feet below coal No. 6. The thickness of the sand is quite variable. In Fyke No. 1 well an intermediate sand which is about 15 feet above the Wilson is the oil producer. It is not improbable that these two sands may be the same with a shale parting in places. A lower sand which contained oil was struck in Tilton No. 1 well at a depth of about 160 feet below coal No. 6. The same sand was reported dry in Fyke No. 1 well.

As shown on the map the producing wells are within the 75-foot structure contour and above the small terrace which is shown on the south flank of the dome. The field may be extended a little to the south but probably not so far as the Overback well, in the SW. $\frac{1}{4}$ section 32, which is within the 70-foot contour, and which struck salt water in a sand about 150 feet below coal No. 6. This sand may correspond to the Tilton. None of the higher sands were reported, and they may pinch out south of the present producing area. Since the Sherman well did not go below the Dykstra sand, the height to which the oil may extend in the dome is not known. Tests should be made to determine this level. What effect the small fault has had upon oil accumulation on the north flank of the dome can not be stated, for no tests have been made between the Sherman well at the top of the dome and the McClelland well, SW. $\frac{1}{4}$ sec. 20, T. 2 N., R. 1 E., which is at the base of the dome.

From a study of the drill records of the area, the shallow sands are irregular in thickness and probably spotty in character. In view of such facts, there is considerable uncertainty attached to prospecting. Accurate records should be kept of all drilling.

Drilling should be extended to the deep sands which have been found productive in both the Sandoval field and the sections east of Centralia and Central City. The lowest of these sands would probably be not more than 920 to 970 feet below coal No. 6. The nearness of the Junction City dome to the Sandoval field and the similarity of the two structures, in the fact that their structural elevations are nearly the same, are ample incentives for deeper drilling.

SANDOVAL DOME

The Sandoval oil field has been described in the Illinois State Geological Survey Bulletin 16, pages 130 to 146. The present producing area is shown on Plate VIII. The structure contouring of the field was done more for the purpose of showing the relation of the Sandoval dome to the structures to the southwest than to give additional information on the producing

field, for its limits have already been outlined by the drill. The difference in the general structure of the field is due to more accurate elevations available since the publication of the topographic map covering the area. As these elevations were used in drawing up the structure to the southwest, it was necessary to make a rough revision of the Sandoval structure.

The oil comes from two sands, the upper or Stein sand being found between 800 and 860 feet below coal No. 6; the lower or Benoist sand, between 900 and 970 feet below coal No. 6 or 100 to 140 feet below the top of the Stein sand. An intermediate sand has been reported in some drill holes, but so far as known it is not productive. However, it may contain salt water with the underlying Benoist sand productive.

The Sandoval field has been producing steadily since the spring of 1909 with a decline less than the average for other Illinois fields. Initial production of wells varies from 50 to 200 barrels per day. At the present time there are nearly 125 wells with a total daily production of about 1,000 barrels.

There are still latent possibilities in the Sandoval structure. In all probability the Chester group contains other sands lower than the Benoist. There may be present, also, the oolitic beds of the Ste. Genevieve which is the McClosky sand of the Lawrence-Crawford County field. These horizons should be tested under the highest part of the Sandoval dome in order to establish their productive or non-productive character.

SHATTUC TERRACE

The Shattuc terrace, which is named from the village on the north side of the structure, occupies parts of secs. 9, 10, 14, 15, 16, 17, 20, 21, 22, 23, 27, 28, and 29, T. 2 N., R. 1 W. On the terrace the average depth of coal No. 6, upon which the structure is drawn, is about 25 feet below sea level. With the surface elevation known, the depth of the coal is easily computed. The Stein and Benoist sands, which are productive in the Sandoval field, will probably be found at a depth of about 840 to 870 feet and 950 to 1,000 feet, respectively, below coal No. 6. The only well near the terrace, the drill record of which is available, is in the NE. $\frac{1}{4}$ sec. 13, T. 2 N., R. 1 W. A 60-foot sand, about 850 feet below coal No. 6 and at the position where the Stein sand should be, had an oil show in the upper part under which was salt water. A second sand 49 feet thick, which would probably correspond to the Benoist sand, was struck at a depth of about 985 feet below coal No. 6. A third sand, 40 feet thick, was reached at a depth of about 1,045 feet below coal No. 6.

More than one well would be required to test the terrace, but with present information the NE. $\frac{1}{4}$ sec. 22, T. 2 N., R. 1 W. would be as favorable as any that might be chosen for a first test.

HOFFMAN ANTICLINE

The Hoffman anticline is apparently a southwest extension of the general anticlinal structure which includes the Sandoval dome and the Shattuc terrace. The Hoffman anticline is well defined from its northern end, which is in secs. 28 and 29, T. 2 N., R. 1 W. Beyond this point, toward Nashville, the structure is less distinct, probably joining with the anticline which extends southwest from Centralia.

The same sands, the thickness and positions of which have been described under the subject "Shattuc terrace", in all probability underlie the area covered by the Hoffman anticline. The drill hole in the SW. $\frac{1}{4}$ sec. 12, T. 1 N., R. 2 W., which is apparently very close to the axis of the anticline, went to a depth of about 825 feet below coal No. 6 but did not reach the horizon of the Stein sand. The location was a good one to test the structure and it is to be regretted that drilling was discontinued before either of the possible oil horizons was reached. Further tests on the anticline should be made on the higher parts first.

PARTS OF HARDIN, POPE, AND SALINE COUNTIES

By Charles Butts

Of the U. S. Geological Survey in cooperation with the State Geological Survey

OUTLINE

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GEOLOGY

STRATIGRAPHY

The rocks of the area under discussion are of Devonian and Mississippian ages. In the center of the Hicks dome (Pl. IX), occupying the high ground about a square mile in extent, is a gray limestone yielding abundant surface chert. This chert incloses such characteristic Onondaga ("Corniferous") limestone fossils as *Amphigenia curta*, *Nucleocrinus (Verneuilli)* ? *Spirifer divaricata*, *Spirifer varicosus*, an *Eatonia*, and other species represented by poorly preserved specimens. This limestone has been regarded as "Tullahoma" [Fort Payne] by Bain and others, but there can be no doubt of its Onondaga age. The central limestone area is surrounded by a belt of valley ground one-third mile wide occupied by the outcrops of the black Chattanooga shale. All observations indicate that this shale is not less than 300 feet thick, and it may be as much as 400 feet, although its thickness has hitherto been estimated at 50 to 100 feet. Overlying the Chattanooga is about 1,500 feet of limestone, made up in ascending order, of the Fort Payne ("Tullahoma") formation, 600 feet; limestone of probable Warsaw age, 250 feet; St. Louis limestone, 350 feet; and the Ste. Genevieve limestone, including the Ohara limestone member at top, 270 feet. Above this series lie alternating limestone, shale, and sandstone strata of the Chester group aggregating a thickness of about 900 feet. These Chester beds outcrop in a belt about 2 miles wide, west, northwest, and north of the semicircular sandstone ridge lying just east of Grand Pierre Creek and southwest and south of Pinhook Creek. The sandstone of this

ridge is the lowest prominent sandstone of the Chester group. The top sandstone of the Chester group (Palestine sandstone of Weller), 150 feet below the basal Pennsylvanian ("Coal Measures") conglomerate, forms the surface of the central part of the Horton Hill anticlinal area. The high hills west of Grand Pierre Creek and north of Rose Creek are capped by Pennsylvanian ("Coal Measures") conglomerate, sandstone, and shale.

STRUCTURE

The structural features in northwestern Hardin County, Ill., include from southeast to northwest the Hicks anticline, the Eagle Valley syncline, the Horton Hill anticline, the Potato Hill syncline, and the Bald Hill anticline.

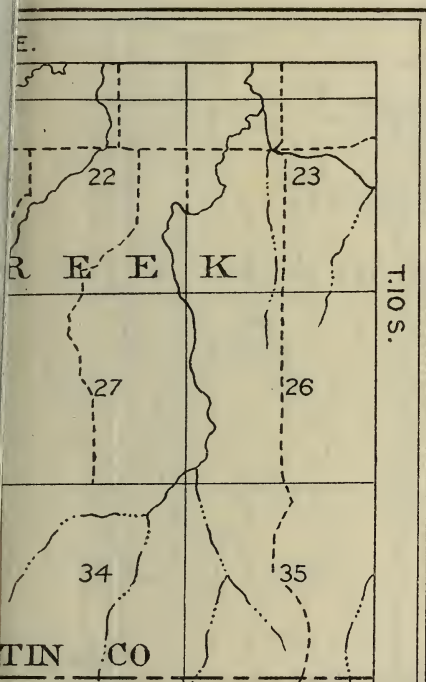
The Hicks anticline is a strong fold long known as the Hicks dome; farther northwest, mainly in southeast Saline County but extending southwestward into northern Pope County, is a low oval anticline here named the Horton Hill anticline; and a mile or two still farther west is a strong unsymmetrical anticline, extending from Lusk Creek in sec. 24, T. 11 S., R. 6 E., northeastward through Bald Hill, and hence called the Bald Hill anticline.

The form and extent of the Hicks dome and of the Horton Hill anticline are shown on the accompanying map (Pl. IX) by structure contours, those on the Hicks dome being drawn on the top of the black Chattanooga shale at vertical intervals of 100 feet, and those on the Horton Hill anticline drawn on the top of the uppermost sandstone of the Chester group (Palestine sandstone of Weller) at vertical intervals of 50 feet. Only the approximate position of the axis of the Bald Hill anticline is indicated, owing to its narrowness, steep northwest limb, and less well-known details.

Between the Hicks dome and the Horton Hill anticline is the Herod fault and a syncline provisionally named the Eagle Valley syncline. The Herod fault trends northeast, and the strata are downthrown on the southeast side about 100 to 200 feet. Between the Horton Hill and Bald Hill anticlines is the Potato Hill syncline, the axis of which lies near and just west of Potato Hill in the SW. $\frac{1}{4}$ sec. 18, T. 11 S., R. 7 E.

Two faults cut into the northeast flank of the Hicks Dome and the most southeasterly one may pass across the dome. About 2 miles farther southeast, and outside of the area mapped, another fault cuts across the Hicks anticline in a general northeast-southwest direction like the mapped faults.

From the center of the Hicks dome the rocks dip outward strongly to the southwest and northeast and intermediate directions with dips between 10 and 20 degrees; the dip is more gentle to the southeast. In broad areas to the southwest and to the north of the center of the dome, the dip is low or the strata are nearly flat. This flattening of the structure,



LEGEND

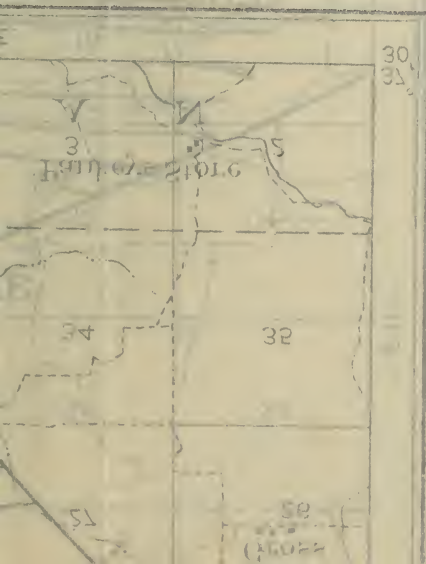
County line

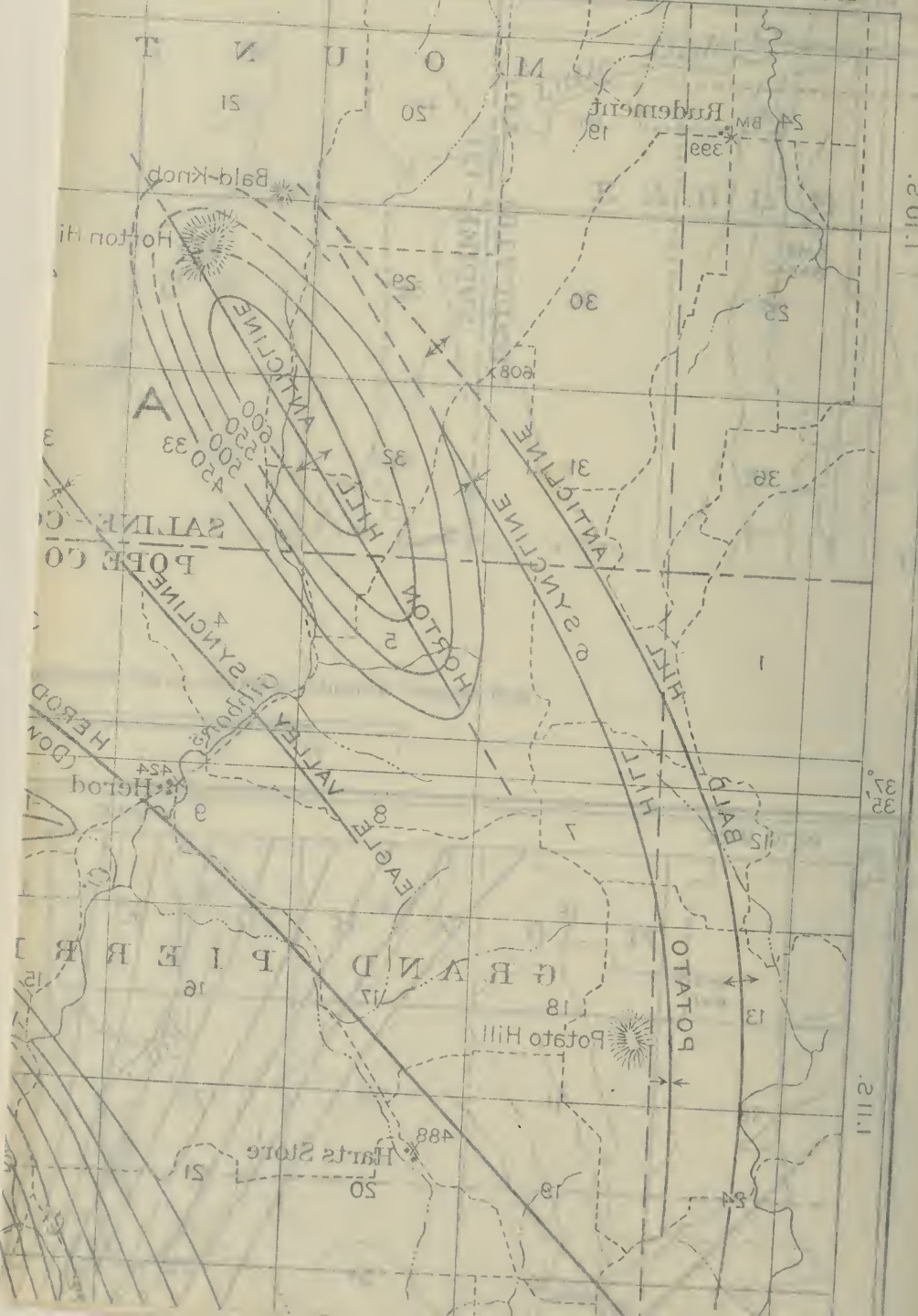
Township line

Section line

Houses and first-class roads

BM X 546 Bench mark





producing a structural terrace, is indicated by the spreading of the contour lines in secs. 13, 34, and 35, T. 11 S.; secs. 2 and 3, T. 12 S., R. 7 E. and secs. 17 and 18, T. 11 S., R. 8 E. Outward from these terraces the dip steepens to about 10 degrees which prevails to the outer margin of the contoured area southeast of the Herod fault. Beyond the contoured area the rocks dip at angles less than 5 degrees as far as the axis of the Eagle Valley syncline, but the continuity of the strata is interrupted by the Herod fault.

West of the Eagle Valley axis the strata rise westward at a small degree to the axis of the Horton Hill anticline. This seems to be an elongated dome, the axis of which pitches moderately to the northeast and to the southwest from the center of the dome. Northwest of this axis the rocks dip northwestward at a low angle to the axis of the Potato Hill syncline. From the last named axis the strata rise westward to the axis of the Bald Hill anticline at a rate gradually increasing to as much as 25 degrees, locally, near the axis. Immediately west of the axis the dip varies from 15 to 60 degrees westward, the steeper dips being observed in secs. 12 and 13, T. 11 S., R. 6 E. and in sec. 31, T. 10 S., R. 7 E. A short distance west of the axis the rocks are nearly horizontal.

POSSIBLE OIL-BEARING STRATA

In the central part of the Hicks dome the possible sources of oil lie below the limestone of Onondaga age. Of these lower strata nothing directly is known in the region, since they are nowhere exposed at the surface and have not been penetrated by deep wells. Rocks that normally occupy this stratigraphic position outcrop in Union and Alexander counties, Ill., 50 miles west of Hardin County; and along Tennessee River 70 miles and farther south of the region. From the Devonian and Silurian rocks of these regions must be inferred the possible character of the corresponding part of the general geologic column in Hardin County. According to Savage,¹ in Union and Alexander counties these rocks include limestone of Onondaga age 150 feet thick, sandstones and cherty limestone of Oriskany age 235 feet thick immediately underlying the Onondaga limestone of Illinois reports, limestone of Helderbergian age 160 feet thick; limestones of Silurian age 120 feet; and sandstone of Richmond age, the Thebes sandstone of Illinois reports, 90 feet thick, lying about 530 feet below the limestone of Onondaga age. If the section of these lower strata in Hardin County is at all like what it is in Union County, it is possible that some of these sandstone beds underlie the Hicks dome at a depth of not over 1,000 feet below the top of the Chattanooga shale. These strata

¹Savage, T. E., Lower Paleozoic stratigraphy of southwestern Illinois: Ill. State Geol. Survey, Bull. 8, pp. 103-116, 1907.

are nowhere known to be oil-bearing, but that is not necessarily a condemnation, for in the Colmar field in McDonough County, Ill., the oil is in a local sand of Niagaran age, and in Allen County, Ky., the oil is reputed to be in rock of Niagaran age. These are recent discoveries and apparently the only occurrences of the kind. There is always a chance of oil occurring at horizons at which it has not been found elsewhere.

Farther out from the center of the Hicks dome, as on the structural terraces previously mentioned, there is, in addition to the chance of oil in the strata below the limestone of Onondaga ("Corniferous") age, the chance of its presence in that limestone itself, which is the oil-bearing stratum of the Irvine field in eastern Kentucky, of the field in Ohio County, Ky., and of the oil fields of Ontario, Canada. The lower part of the limestone of Onondaga age in Union County, Ill., is said to have a strong odor of petroleum. The top of this limestone should be reached at about 1,600 feet below the general level of the country in the area of the structural terraces in secs. 13, 34 and 35, T. 11 S., R. 7 E.; secs. 2 and 3, T. 12 S., R. 7 E.; and sec. 17, T. 11 S., R. 8 E.; and the possibly oil-bearing strata below the limestone are probably within a depth of 2,200 feet below the general level of the ground in these sections.

In the region of the Horton Hill anticline there is also a chance that the basal sandstone strata of the Chester group may contain oil. The top of these sandstones is at a depth of 500 to 600 feet along the Horton Hill axis, whereas the limestone of Onondaga age is probably about 2,300 feet deep and the horizon of the Thebes sandstone of the Illinois Survey, the lowest possible sandstone, is probably not over 3,000 feet below the top of the upper Chester sandstone in the center of the anticlinal area.

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